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THE CHEMICAL NEWS.

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THE ELECTROLYSIS OF SOLUTIONS OF THE RARE EARTHS. II.*

By L. M DENNIS and R. A. van der MEULEN.

IN the *Journal of the American Chemical Society* (1915, xxxvii., 131) there was described a method for the fractional separation of the rare earths by means of the electrolysis of neutral solutions of their nitrates. The present article describes results that were obtained in a further study of that method.

Dennis and Lemon electrolysed a solution of the nitrates of various rare earths, using a cathode of mercury and an anode of platinum. They did not employ a diaphragm, and consequently it was possible that the separation of the rare earths they obtained might be ascribed to the fractional precipitation of the hydroxides of the earths by the ammonia formed by cathodic reduction of the nitric acid. To ascertain whether the rare earths could fractionally be separated by the electrolysis of solutions of their salts under such conditions as would preclude the formation of ammonia, a solution of the chlorides of the earths was subjected to electrolysis.

I. *Electrolysis of a Neutral Solution of the Chlorides of the Rare Earths.*

Material.—The material that was employed for this electrolysis consisted of about 1200 grms. of the oxides of the yttrium group from which the cerium had been separated by chlorination, and almost all of the didymium earths had been removed by precipitation with sodium sulphate. The purified material contained neither iron nor other common elements, and its solution showed no absorption bands of neodymium.

A neutral solution of the chlorides of these earths was prepared by slowly adding the oxides to warm dilute hydrochloric acid until the oxides were in slight excess.

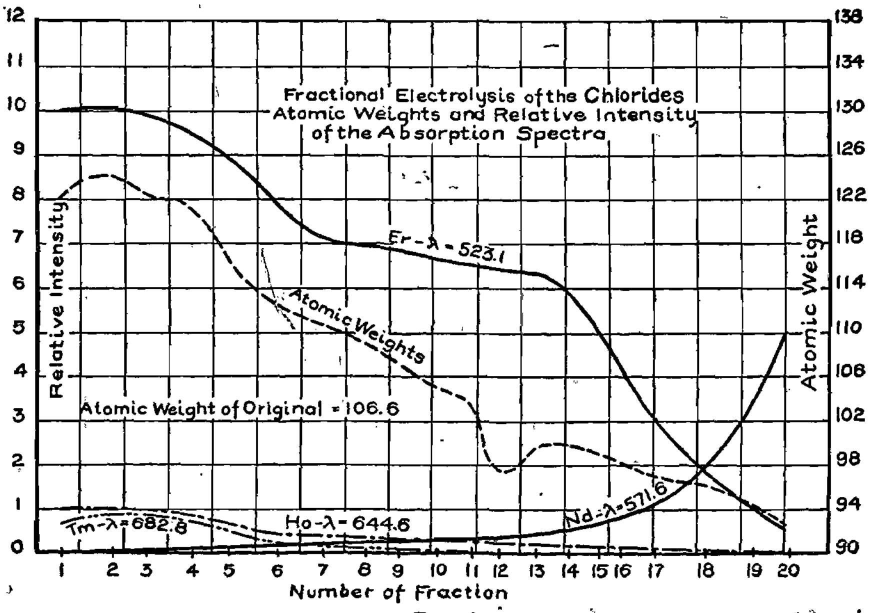

FIG. 1.

* From the *Journal of the American Chemical Society*, xxxvii., No. 9.

The liquid was then heated to boiling in the presence of the excess of oxides until a test with Congo-red paper showed that all of the acid had been neutralised. The undissolved oxides were then removed by filtration, and the filtrate was diluted with distilled water until it contained an amount of the chlorides equivalent to 10 per cent by weight of the solution in oxides of the rare earths.

Apparatus.—The cell that was used for the electrolysis was a thick-walled glass cylinder with an internal diameter of 32·5 cm. and a depth of 35 cm. A layer of mercury 1·5 cm. deep was placed in the bottom of this cylinder, a glass cup filled with mercury was set in the middle of the bottom of the cylinder, and a porous cup 5 cm. in diameter and 12 cm. high was placed upon this glass cup base. Electrical connection with the layer of mercury was made by fusing a short platinum rod through the end of a glass tube, filling the tube with mercury, and then fastening this tube in such position in a clamp that the projecting end of the platinum dipped into the mercury in the cylinder. A cylindrical carbon rod, 2 cm. in diameter and 30 cm. long, inserted in the porous cup served as anode. The chlorine gas that was liberated at the anode was carried off to the flue by fitting the top of the porous cup with a perforated rubber stopper, and blowing a current of air through the cup. The neutral solution of the chlorides of the rare earths was poured into the cell upon the layer of mercury, and this solution and the mercury were vigorously stirred throughout the electrolysis by air that was blown through three glass tubes that dipped below the surface of the mercury. Current for the electrolysis was taken from a 110 volt direct circuit through a lamp bank. An ammeter was connected in series with a cell and a voltmeter was connected across the terminals.

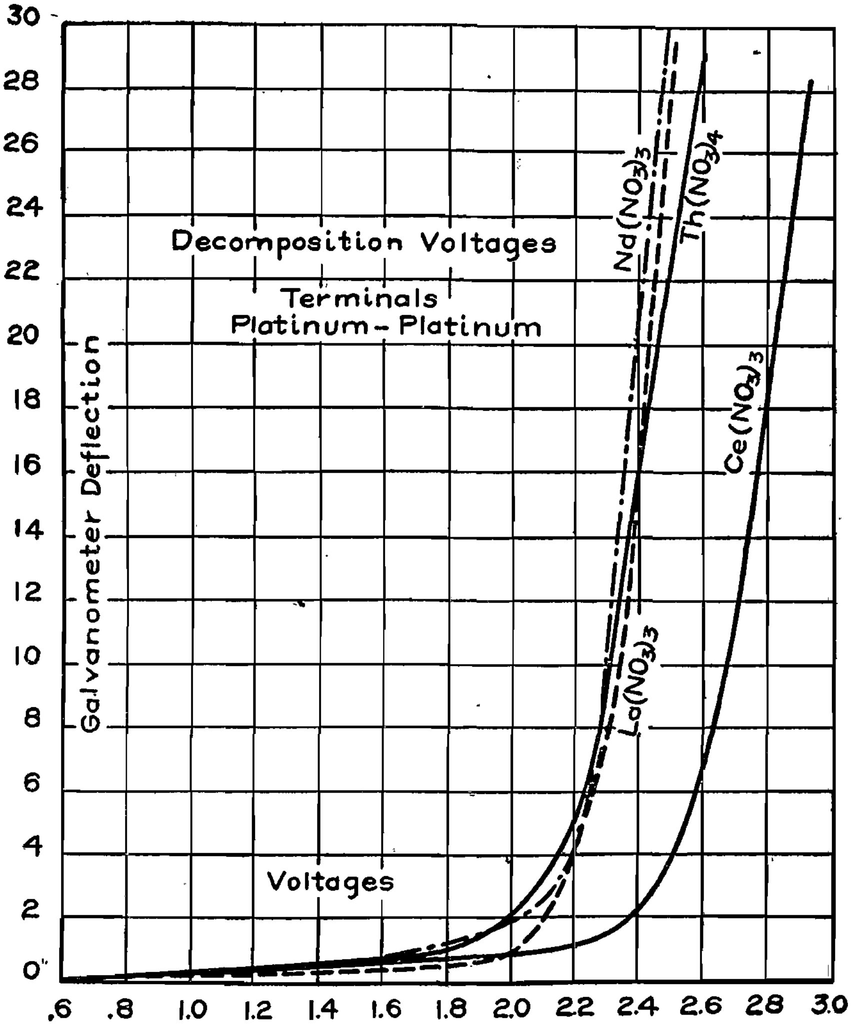

Fig. 2.

Procedure.—After the cell had been charged in the manner above described, the porous cup was placed upon its support in the middle of the cell, and was filled with dilute hydrochloric acid (0·1 N) until the level of the acid inside the cup was slightly below the surface of the solution in the cell. The carbon anode was then set in position within the cup, connections with the source of current was made, the air for stirring the mercury cathode was turned on, and the electrolysis was continued until the equivalent of about 40 grms. of oxides of the earths had been precipitated at the cathode in the form of hydroxides.

The character of the hydroxides obtained in this manner is entirely different from that which results from the precipitation of a solution of the earths with an alkali hydroxide. The electrolytic precipitate is granular, and appears to possess a crystalline character, although a microscopic examination failed to show crystalline characteristics.

When the desired amount of the rare earths had been precipitated, the current was turned off, the agitation of the mercury cathode by air was discontinued, the precipitated hydroxides were allowed to settle, and the supernatant liquid was syphoned off. The precipitate and the mercury at the bottom of the cell were transferred to a separatory funnel, and the mercury was drawn off. The hydroxides were then thrown upon a Büchner funnel and were thoroughly washed with water. They were next warmed with dilute hydrochloric acid, which dissolves the hydroxides readily, but left most of the finely divided mercury undissolved. The undissolved mercury was separated by filtration, and the small amount of mercury that had passed into solution was removed by precipitation with hydrogen sulphide. The filtrate was freed from hydrogen sulphide by boiling, and the rare earths were then precipitated by oxalic acid. The oxalates were washed with hot water until free from chlorides, and were then dried. A small portion of this precipitate of the oxalates was set aside for the determination of the average atomic weight of the earths, and the remainder of the oxalates was converted to the oxides by heating in a platinum dish.

The supernatant liquid that was syphoned off from the hydroxides precipitated during the electrolysis, and the wash water from the washing of these hydroxides were united, placed in the cell, and the electrolysis was repeated until the second fractional precipitate of hydroxides of the earths was obtained. This precipitate was purified as before, and the procedure was repeated until nearly twenty fractions resulted. As the end of the fractional precipitation was approached, the voltage across the terminals of the cell rose because of the decreasing concentration of the electrolyte.

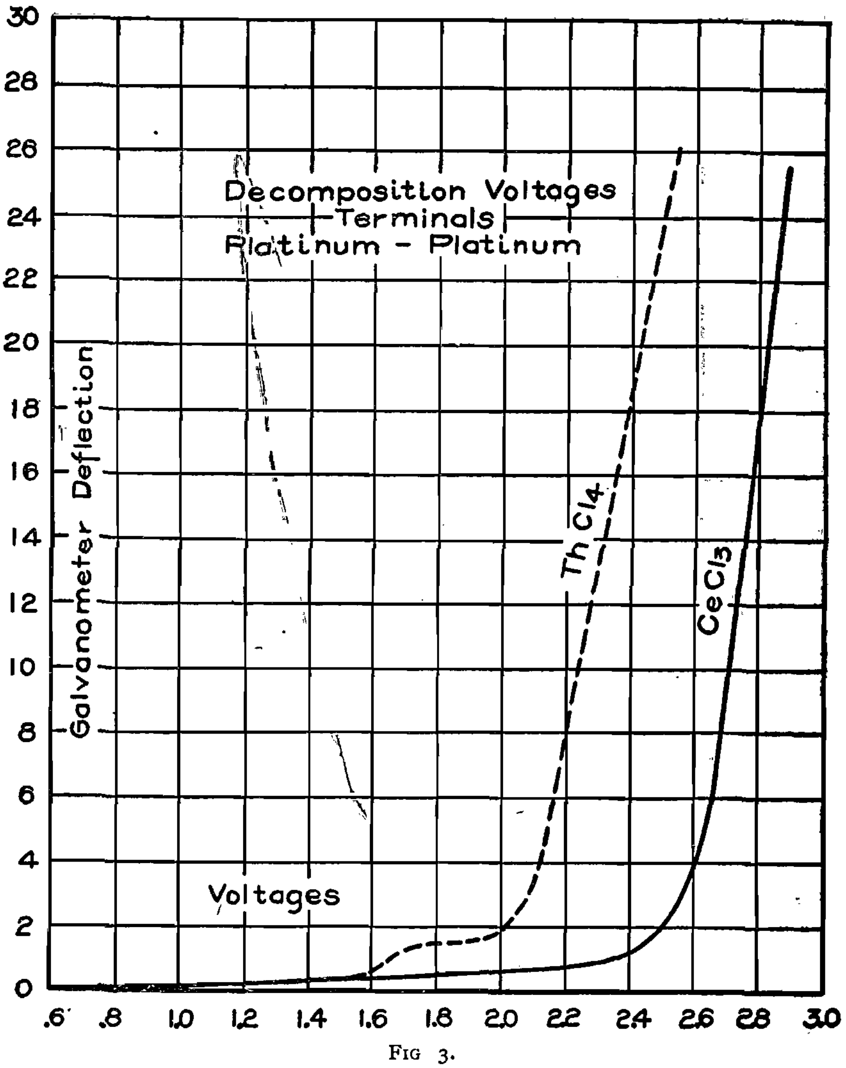

FIG 3.

The atomic weight of each fraction was determined by the oxalate-oxide method. The absorption spectrum of each fraction was observed with a Krüss spectroscope in the manner described by Dennis and Bennett (*Journ. Am. Chem. Soc.*, 1912, xxxiv., 7). The solution employed for

his purpose was prepared by dissolving 5 grms. of the oxide in a slight excess of hydrochloric acid, removing the excess of acid by evaporation and diluting the solution to 25 cc. with distilled water. Whenever Congo-red paper showed there was still an excess of acid, the evaporation was repeated until the free acid was removed.

The details of this series of electrolyses are given in Fig. 1. The atomic weights of the various fractions and absorption spectra of the fractions show that the coloured earths, erbium, holmium, and thulium, are concentrated in the early fractions. Neodymium, which was present in the original solution in such slight amount that its absorption bands were not discernible, was concentrated in the later fractions. The low atomic weights of the last four fractions show that yttrium is precipitated chiefly in the later fractions.

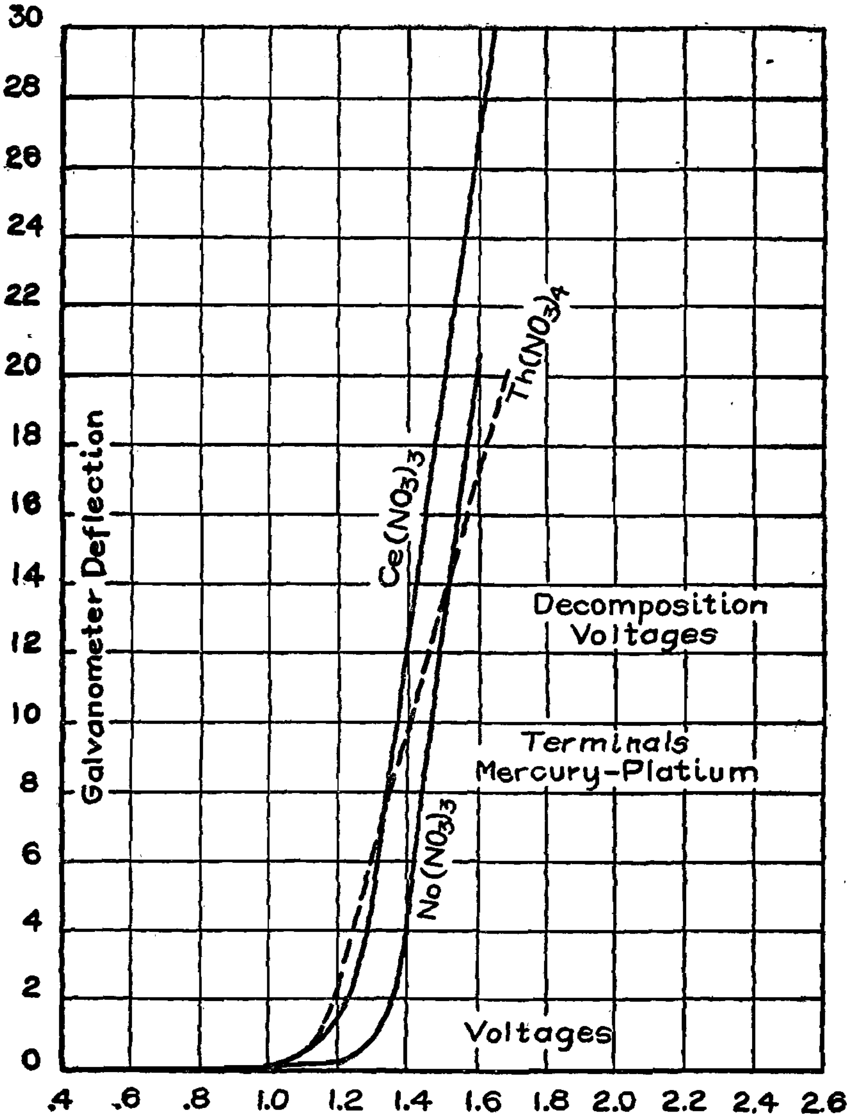

FIG. 4.

the relative intensities of distinctive absorption bands of the different coloured earths in the fractions are plotted in Fig. 1. The spacing of the fractions along the axis of abscissas is based upon the actual weights of the several fractions.

The results obtained in the above fractional electrolysis of a neutral solution of the chlorides of the rare earths demonstrate that the earths of the yttrium group can fractionally be separated under conditions that preclude the formation of ammonia or other basic precipitant. The voltage that was employed in the electrolysis of the chlorides was undoubtedly considerably higher than the decomposition voltage of the salts of the various rare earths that were present. The question naturally arose as to whether the decomposition voltages of the salts of the rare earths might be utilised in obtaining a sharper separation of the different earths than seemed to be possible with higher voltage. To obtain information upon this point the following experiments were made.

TABLE I.—*Original Atomic Weight*, 106·6.

Fraction No.	Atomic weights.	Weight oxides (grms.).	Volts.	Ampere hours.
1	121·98	26	8·4	100
2	123·79	57	8·5	154
3	122·12	42	8·4	114
4	121·16	54	8·0	121
5	115·55	36	8·0	87
6	113·37	55	8·2	150
7	110·71	56	7·5	155
8	108·69	46	9·2	143
9	106·74	40	8·0	141
10	104·28	44	8·5	129
11	103·11	40	7·5	109
12	97·09	30	8·0	97
13	98·87	40	10·1	164
14	99·03	38	9·0	132
15	98·63	36	8·5	110
16	98·27	25	10·0	170
17	96·53	40	10·5	137
18	96·12	55	10·9	152
19	94·28	50	11·0	153
20	93·16	41	13·0	179

Remarks.—Oxalates pink, colour deepened through No. 4, after which it faded; the oxalates of fractions 19 and 20 were almost white. The oxides were of a brownish yellow colour, which deepened to fraction 4 and then gradually became lighter.

II. *Decomposition Voltages of Solutions of Salts of the Rare Earths.*

(Mr. A. B. Ray, who is also carrying on investigation in this field, collaborated in the determination of these decomposition voltages).

The solution of the rare earth under examination was placed in a small U-tube of 9 cc. capacity and 8 mm. internal diameter. Dipping into the solution in the two arms of this tube were two terminals of platinum wire. These were cleaned with care, and heated to redness before each determination. These terminals were connected through a galvanometer and switch to a slide wire-resistance, by means of which a gradual change of potential from zero to three volts could be obtained. This potential difference was accurately measured by means of a standard voltmeter that was sensitive to 0·002 volt. The current flowing through the cell was measured by the deflection of a galvanometer which was observed through a telescope. The resistance of the galvanometer was so small that the error caused by placing it in series with the cell was negligible. That such was the case is shown by the fact that when a potential difference so slight that it could not be read on the voltmeter was established between the terminals, with the cell cut out, the deflection of the galvanometer was beyond its highest scale reading.

The solutions of the rare earths that were employed in these measurements were prepared by precipitating the hydroxides of the earths with ammonium hydroxide, washing the precipitate on a Büchner funnel with hot water until it was free from ammonium salts, and then bringing the precipitated hydroxide into contact with an amount of the acid that was just insufficient to dissolve all of the precipitate. The solution was boiled for several minutes with the excess of the hydroxide to ensure complete neutralisation of the acid. The residual precipitate was then removed by filtration. The concentration of the solution was determined by analysis, and it was then diluted with water until it was of exactly normal strength.

In this manner normal solutions of the nitrates of thorium, lanthanum, cerium, and neodymium and of the chlorides of thorium and cerium were prepared.

The decomposition voltage of one of these solutions was determined by placing the solution in a U-tube, making connections in the manner above described, and then gradually raising the potential difference across the cell by increasing the external resistance. With each change of potential, connection with the galvanometer was made by throwing in the switch, and the reading of the instrument was taken after the initial momentary deflection had subsided. As the decomposition value, which had to be located approximately beforehand, was approached, very small increments in potential were taken, which gave a large number of points in this region. From the readings thus obtained curves were plotted, using potential differences as abscissas and the galvanometer deflections as ordinates. The point at which the curve shows a decided break is the decomposition value. Sometimes the curve, after passing this point, showed peculiar behaviour in that it did not rise in a straight line. This was probably due to slight electrolytic decomposition and deposition at one or the other of the terminals. In every case, however, the break came at the same point.

The results that were obtained in the measurement of the decomposition voltages of neutral solutions of the nitrates of thorium, neodymium, lanthanum, and cerium, using terminals of platinum, which are plotted in Fig. 2, were as follows:—

TABLE II.

	Volts.
Thorium nitrate	1·87
Neodymium nitrate	2·03
Lanthanum nitrate	2·05
Cerous nitrate	2·18

The decomposition voltages of neutral solutions of the chlorides of thorium and cerium with terminals of platinum are shown in Fig. 3, and were—

TABLE III.

	Volts.
Thorium chloride	1·94
Cerous chloride	2·36

It was further thought desirable to ascertain the decomposition values of some of these salts under conditions that simulated as closely as possible those pertaining in the fractional electrolysis with an agitated mercury cathode.

The container that was here employed consisted of a glass tube with a platinum wire sealed through the closed lower end and a side arm sealed to the tube a short distance above the lower end and bent upward. Mercury was poured into the larger tube until the level of the metal reached nearly to the opening of the side tube, and the main tube and side arm were then filled nearly to the top with the solution under examination. The mercury was kept in agitation by bubbling air through it, the air being passed in through a small tube inserted from above. A platinum wire extending down a short distance into the solution in the side arm served as anode. The results that were obtained with this apparatus are plotted in Fig. 4, and were as follows:—

TABLE IV.

	Volts.
Thorium nitrate	1·06
Cerous nitrate	1·10
Neodymium nitrate	1·24

These measurements show that the decomposition voltages of solutions of such salts of the rare earths as were here employed lie quite close together, and usually increase with the increase of the basicity of the earth. The decomposition voltages of the nitrates of thorium, neodymium, and cerium, when a mercury cathode and platinum anode are employed, are considerably lower than the values obtained between platinum terminals, but the differences are no more pronounced. From these results it is apparent that a sharp separation of the different earths one from another cannot easily be effected by adjustment of the voltage. Moreover, the precipitation of the hydroxides of the earths at these low voltages is so slow as to, of itself, preclude the utilisation of these decomposition values in the rapid fractionation of compara-

tively large amounts of the rare earths. For these reasons recourse was again had to the fractional electrolysis of solutions of voltages considerably above the decomposition values. Preliminary experiments having shown that no ammonia is formed when a solution of the nitrates of the earth is electrolysed with a mercury cathode, and with a platinum anode that is placed in a porous cup, this modification of the procedure was next subjected to examination.

(To be continued).

THE WORLD'S SUPPLY OF NITROGENOUS FERTILISERS.

By Dr. GEORGE W. ANDERSON.

The war has brought home to farmers as well as to the people at large the importance of artificial manure in order to increase the yield of our home-grown products; but owing to the enormous consumption of the munition industry, private consumers had to be cut short of their requirements, particularly as regards nitre, whereas sulphate of ammonia was available in limited quantities. The prices for nitrogenous fertilisers have advanced with the increasing demand and the cost of production, so that consumers are looking forward to a revision of the present prices, which is expected in view of the enormous quantities now available, as the demand for ammunition has ceased.

The total world's production of nitrogenous fertilisers and products has been increased considerably during the war; so that great competition will ensue, in which Germany is likely to play an important part. The whole question is of such vital importance that it warrants a close scrutiny of both the present and the future situation.

The following resources of nitrogen are available for supplying the world with nitrogenous products:—

1. Natural nitrate of soda, occurring as a mineral chiefly in Chili, besides smaller deposits in India, &c.
2. Nitrolim, calcium cyanamide, which is artificially produced from calcium carbide and nitrogen of the air with the aid of a strong electric current. In the beginning its production was chiefly confined to countries with large water-power, such as Norway and the United States; but it is now being manufactured in practically all countries.
3. Artificial nitrate of lime, chiefly produced from oxygen and nitrogen of the air with the aid of an electric arc. Owing to the heavy consumption of electricity it is almost solely manufactured now in Norway—the country of cheap water-power.
4. Ammonia as a by-product of coal distillation, chiefly recovered in gasworks, coke-ovens, the shale industry, and, in smaller quantities, from gas producer plants.
5. Synthetic ammonia, which may be either produced by the combination of nitrogen and hydrogen (Haber process) or by the action of steam on calcium cyanamide.

Ammonia is easily oxidised, forming nitric acid (Ostwald process), and thus becomes a source for the production of nitrates.

Nitrate.

Before the war practically all countries were supplied with nitre from Chili, the production of which was increasing from year to year, owing to an excellent organisation of the Chilian industry and very extensive sale propaganda. The total yield, which in 1900 only amounted to 1·42 million tons, reached in the last pre-war year (1913) 2·7 million tons. After the outbreak of war the exports suffered a considerable recession, and, in consequence, the production had to be restricted, so that in 1915 only 1·72 million tons of nitre were produced. However, this loss was soon made up by the increasing demands of the allies, particularly of the United States; the total output of nitre there in 1917 amounting to 2·95 million tons—a figure which is assumed to have also been reached in 1918. The United States alone imported in 1917 some 1·4 million tons, of which 45 per cent was required for the manufacture of munitions and 20 per cent for agricultural purposes. It is assumed that rural consumers in America will absorb the excess of imported nitre, after the demand for the manufacture of munitions has ceased.

However, as America is not capable of consuming anything like the possible output of Chiliannitre—which is estimated to be something like 73 million quintals = 7·3 million tons (?)—and the European countries will probably require less than during the war, the nitrate producers have an anxious time ahead of them, and may be compelled to reduce their production in order to avoid amassing unwieldly stocks and a consequent recession of prices. The latter have reached an unprecedented figure, as much as 13s. 5½d. f.o.b. Chili being paid per quintal of unrefined nitrate; whereas in the first half year of 1914 only about 6s. per quintal was quoted.

According to a late announcement of the Board of Agriculture, a certain amount of nitrate is now available for farmers at £20 per ton (90 per cent pure), which does not compare favourably with the maximum price for sulphate of ammonia fixed at £16 16s. 6d. per ton, which contains about 20·5 per cent of nitrogen, as compared with about 15 per cent of nitrogen in the nitrate of soda. It is fully expected that other nitrogenous fertilisers will take the place of nitrate, and that nitrate of soda will hardly regain its former predominant position in the world's market. Although the nitrate industry would be able to reduce the present prices considerably if the Chilian Government would grant a reduction of the export tax, which now amounts to about 4d. per kilogrm., £16 13s. per metric ton, of nitrogen (= about £2 10s., per ton of nitrate), the prohibitive prices of coal and the shipping freights will prevent this industry from seriously endangering the position of artificial and other nitrogenous fertilisers which gain more ground every day. This refers particularly to the enormously increased production of artificial fertilisers in Norway and Germany, both of which come into consideration when the European market is concerned.

Norwegian Saltpetre.

Nitrate of lime is produced in Norway from atmospheric oxygen and nitrogen with the aid of the electric arc, to a limited extent; the total output reaching in 1913 only 70,000 tons, and in 1918 45,000 tons. The production of this fertiliser has not developed to the extent at first anticipatee, as the cost of production is rather high, owing to the enormous consumption of electric current. For 1 ton of calcium nitrate (13 per cent N) from 10,000 to 12,000 units are required, whereas calcium cyanamide (18 to 20 per cent N) can be produced with about one-third of this quantity of electricity (3800 units). In consequence, the production of the former has been limited to countries where cheap water-power is available.

Nitrolim (Calcium Cyanamide).

The enormously increased world's production of nitrolim reached in the last pre-war year the considerable total figure of 285,000 tons, which now it may safely be assumed is largely exceeded, as in most countries existing plants were enlarged and new ones added. In Germany, where in 1913 only 52,000 tons were produced, plants of a considerable size have been erected during the war by private firms (Bayerische Stickstoffwerke, Knappsack) and the Government (Priesnitz, near Bitterfeld), with a total potential capacity of 635,000 tons = 113,500 tons of nitrogen. The cost of production is estimated to be about 8½d. per kilogrm. of nitrogen—pre-war prices for material being assumed. This figure, however, seems to be underestimated, as the cost of the electric current required for

Table III.—*Production and Consumption of Nitrogenous Products in Germany.*

	Per cent, N.	Consumption, 1913.	Tons, N.	Production, 1913.	Tons, N.	Production, 1919.	Tons, N.
Saltpetre	15·0	750,000	112,500	—	—	—	—
Sulphate of ammonia ..	20·5	460,000	94,300	530,000	108,650	530,000	108,650
Synthetic ammonia ..	—	—	—	35,000	7,170	950,000	195,000
Nitrolim	18·5	87,000	16,000	52,000	9,620	635,000	117,500
Norwegian saltpetre ..	13·0	38,000	5,000	—	—	—	—
Total..	—	1,335,000	227,900	617,000	125,440	2,115,000	421,150

the production of 1 kilogrm. amounts to about 7½d., assuming a current consumption of 19 units per kilogrm. at 0·4d. per unit. However, it seems possible to sell the product at about 1s. per kilogrm. of nitrogen, which compares very favourably with the present prices paid for any other nitrogenous product in England or elsewhere. Germany is not able to consume the quantity produced, and will naturally seek to export the excess, which is particularly favourable, as long as the rate of exchange is against her.

Table I.

Exported to—	Germany Tons.	England. Tons.	Total exports. Tons.
Belgium	15,775	5,169	20,944
France	7,428	8,964	16,392
Italy	3,551	5,922	9,473
Netherlands	18,195	2,872	21,067
Switzerland	1,337	—	1,337
Spain..	2,550	52,382	54,932
Denmark	455	—	455
India	16,024	38,046	54,070
Hawaii	2,541	7,143	9,684
British Guiana ..	—	6,549	6,549
Japan..	—	114,648	114,648
Mauritius..	—	4,976	4,976
North America ..	5,630	37,067	44,697
Central America ..	—	—	—
South America.. ..	428	—	428
Brazil..	—	—	—
West Indies	—	2,459	2,459
British India	818	—	818
Other countries ..	1,136	30,051	31,187
Germany	—	8,453	8,453
Total	75,868	324,701	400,569

Synthetic Ammonia and Sulphate of Ammonia.

A somewhat alarming figure has been reached by the production of synthetic ammonia in Germany, which is chiefly manufactured by the Badische Anilin und Soda Fabrik at Ludwigshafen (the Haber process). It is maintained by the manufacturers that it represents the cheapest way of producing nitrogenous fertilisers; the synthetic ammonia being particularly suitable for conversion into nitric acid on account of its great purity. The above-named firm have plants of a potential capacity of 950,000 tons (calculated as sulphate of ammonia) = 195,000 tons nitrogen per annum, and are supposed to produce ammonia at 6d. per kilogrm. This, however, seems rather low, as the hydrogen and nitrogen required for the process would cost 2d. alone, viz.:—

1·00 kilogrm. N_2 = 1·61 cb.m. at 0·5d. = 0·805d.
0·212 kilogrm. H_2 = 2·41 cb.m. at 0·5d. = 1·205d.

2·010d.

This figure may safely be taken to be twice as high, as other costs involved in the manufacture of sulphate of ammonia are not taken into account; so that the actual sale price will not be lower than 1s. per kilogrm. of nitrogen (= £10 5s. per ton of sulphate of ammonia). Considering, however, that pre-war prices of sulphate of ammonia varied between 1s. 1d. and 1s. 4d. per kilogrm. of nitrogen (= £11 0s. 1d. and £13 13s. 4d. per ton of sulphate of ammonia), Germany is inta position to compete easily with the natural product, and may greatly endanger our home market. Already before the war the increased production of sulphate of ammonia in Germany disquieted the ammonia market considerably; so that makers could not readily dispose of their products. This was also partly due to the fact that our home consumption did not increase at the same rate as the production—1901, 70,0000 tons; 1912, 90,000 tons—so that the British manufacturers greatly relied on export, where they met with some German competition. Germany had become an exporting country in 1906, after having been unable to satisfy her own demands until taht date. At the same time the total export of the two countries together had not much increased—amounting in 1910 to 345,000 tons, as compared with 400,569 tons in 1913. England had the largest share in the last figure—viz., 324,701 tons; whereas Germany's quantity was 75,868 tons.

The latter seems small in itself, but may be taken as a warning for the future, as Germany's production increased rapidly since 1900 (104,000 tons of sulphate) to 1913 (565,000 tons of sulphate).

Table II.

	Production, 1900. Tons.	Production, 1910. Tons.	Production, 1912. Tons.	Production, 1913 Tons.
Germany	104,000	375,000	492,000	565,000
England	217,000	369,000	379,000	414,700
United States ..	27,000	116,000	151,000	—
France	37,000	56,000	69,000	—
Belgium .. .. } Netherlands .. }	33,000	38,000	50,000	—
Netherlands ..		4,800 }		
Austria-Hungary	35,000	100,000 }	190,000	—
Other countries	10,000	55,000 }		
Total	463,000	1,113,800	1,331,000	—

Conclusions.

From the foregoing it will be seen that the production of nitrogenous products in Germany has been greatly promoted during the war, and that, in consequence, a strong competition may be expected, as Germany will not be able to absorb the total production herself, after the demand for munitions has ceased.

Table III. shows that there is a considerable excess of production over the probable consumption for which the last pre-war figure (1913) may be taken as the outside. Although the cost of production has gone up considerably, German manufacturers were able to write-off their plant during the war, and thus have the great advantage of low capital costs. This, together with the present favourable rate of exchange for exports, places the German trader in an advantageous position.—*Gas Journal*, June 10, 1919.

The British Scientific Products Exhibition was opened at the Central Hall, Westminster, S.W., on Thursday, July 4, by the Marquis of Crewe, K.G., President of the Exhibition, supported by the Rt. Hon. Lord Moulton, F.R.S., and Sir Alfred Keogh, Vice-Presidents. Lord Sydenham, President of the British Science Guild, occupied the Chair. The Exhibition will remain open for the month.

THE RAPID ESTIMATION OF PERCHLORATES, ALONE, OR IN THE PRESENCE OF CHLORATES AND CHLORIDES.

By J. GUILFOYLE WILLIAMS, B.Sc. (Lond), A.I.C.

Perchlorates are usually estimated by fusion to chlorides and subsequent estimation by weighing as AgCl, or by titration with silver nitrate solution. With chlorides and chlorates present these have to be separately estimated and allowed for. The fusion can very satisfactorily be done in a flux of NaOH, as this slows down the reaction and prevents spirting; the chlorides can then be estimated by dissolving, acidifying with nitric acid, and titrating, using Volhard's method.

This process is, however, very tedious where necessary for routine purposes for the analysis of solutions, as it entails slow and careful evaporation. A far quicker method is here given based on the use of titanous chloride.

The method is given briefly in "New Methods in Volumetric Analysis," by Knecht and Hibbert, where it is stated that in the presence of sulphuric acid titanous chloride is oxidised by perchlorates. Working details, however, are not given, and below is described a process fully worked out for this method.

Preliminary experiments established the following facts:—

1. Though dilute $TiCl_3$ solutions oxidise rapidly, strong solutions made by adding 10 cc. of 15 per cent $TiCl_3$ solution to 25—30 cc. of 5 per cent H_2SO_4 do not oxidise appreciably even on boiling for five minutes. The oxidation was estimated by titrating the cooled solution with ferric alum solution using two or three drops of KCNS 10 per cent solution as internal indicator.

2. With $AmClO_4$ in acid solution the oxidation of $TiCl_3$ is very slow in the cold but rapid in hot solutions.

3. To secure complete reaction after boiling for one minute it is necessary that the acid concentration be 30 per cent by volume.

Pure dry samples of $KClO_3$ and $AmClO_4$ were now obtained, and a solution of ferric alum prepared by dissolving 100 grms. in a litre of water. This was then standardised by using 15 cc. of $AmClO_4$ solution of known strength, 10 cc. of 15 per cent $TiCl_3$, and 10 cc. of H_2SO_4, boiling and titrating after cooling. A blank was of course done on the ferric solution required by the 10 cc. of 15 per cent $TiCl_3$ solution. Weighed quantities of chlorate and perchlorate were then taken, 15 cc. of water added, 10 cc. $TiCl_3$, and 10 cc. H_2SO_4, boiled, and titrated. The table below gives results after chlorate had been allowed for.

$KClO_3$ (weighed).	$AmClO_4$ (weighed).	$AmClO_4$ (found).
0·0234	0·1566	0·1527
0·1306	0·0648	0·0612
0·0394	0·1142	0·1119
0·0557	0·1006	0·1007
0·0540	0·1136	0·1138
0·1156	0·0506	0·0505

The method therefore gives a good degree of accuracy, and it was adopted as a routine method. The average time for a duplicate analysis by this method is fifteen minutes. By the fusion method the time required is fifty minutes. It also has the advantage that it gives perchlorate even in a large excess of chlorate, whereas a fusion method fails here, and it is necessary to eliminate chloride and chlorate by evaporating successively with HCl and then with HNO_3—thus leaving only the perchlorate, which is then fused and estimated.

The only precautions necessary in this process are—(a) periodic blank test on the $TiCl_3$ solution; (b) the same time must always be allowed for the pipette to drain off $TiCl_3$, as the solution has a high viscosity, and errors are otherwise likely to occur through unequal volume delivery. An automatic pipette fitted with the usual device for maintaining a hydrogen atmosphere above the $TiCl_3$ solution reservoir is advisable.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, June 19, 1919.

Sir J. J. Thomson, O.M., President, in the Chair.

The Bakerian Lecture was delivered by the Hon. R. J. Strutt, F.R.S., on "*A Study of the Line Spectrum of Sodium as Excited by Fluorescence.*"

A improved form of sodium vapour lamp, in quartz, is described, giving an intensely bright sodium spectrum, admirably adapted for exciting sodium vapour to resonance.

It is found that excitation of sodium vapour by the second line of the principal series leads to the emission of both λ 3303 and the D-line.

On the other hand, as might be expected, excitation by the D-line leads to the emission of the D-line only, without 3303.

If only one of the components of the doublet 3303 is stimulated, both the D-lines are emitted.

When D light falls on sodium vapour, of appropriate density, it is known that an intense surface emission occurs from the front layer, and a weaker one from succeeding layers. Analysis by absorption in an independent layer of sodium vapour shows that the superficial emission is more absorbable, and therefore nearer the centre of the D-line.

The breadth of the D-lines in superficial resonance has been estimated by interferometer methods. It is found to correspond with the breadth conditioned by the Doppler effect, calculated on the assumption that the luminous centre is the sodium atom.

Polarisation could not be detected in the ultra-violet resonance radiation, though in accordance with previous observers, it was readily observed in D resonance.

SOCIETY OF GLASS TECHNOLOGY.

The June meeting of the above Society was held at the University, Sheffield, on June 18, 1919; the President, Mr. S. N. Jenkinson, in the Chair.

The Secretary paid a touching tribute to Mr. Crowther, in whose death the Society have suffered a great loss. Mr. Crowther was one of the original members, and played a considerable part in the foundation of the Society, and had always taken a very keen interest in its doings.

The following papers were read:—

"*Impressions of a Recent Tour of the German Glass Factories.*" By S. N. Jenkinson.

Mr. Jenkinson prefaced the remarks of his experience in Germany by appealing to all members of the Society to pull together as in the past, and to endeavour by all means in their power to increase the prestige of the Society. During his tour in Germany he visited Silesia, Saxony, Saxe-Weimar, and other districts, and investigated conditions in several works, particularly glass factories. The size of the glass industry in Germany in pre-war days can be judged from the fact that in 1913 they exported glass to the value of 123 million marks, and pottery to the value of 94 million marks. This amount means that 75 per cent of their output was exported. It can be realised therefore that the outbreak of war caused the shutting down of many German glass factories during 1914-15. The policy during 1915-16 in Germany was to reopen several of the factories and allow one furnace in each works to be kept going, and a scheme was inaugurated whereby finance in the industry was pooled. At the present time very little production of glassware is taking place, due largely to the lack of coal and the state of transport. Their stocks are very low. Throughout the visit he was very much impressed by the fact that all the plant in the works was kept in the highest pitch of efficiency, so that immediately opportunity came a high rate of production would follow

This fact will have to be taken into account by British manufacturers. Out of some 132 furnaces which he made inquiries about only about 8 were working.

"*Experiments with a Gas Fired Pot Furnace.*" By M. W. Travers, D.Sc., F.R.S.

The author gave a description of furnaces which had been used in producing chemical glassware, and advocated burning the gas from the producers in front of the pots, and taking the burnt gases out of the furnace at the back. He illustrated his remarks by means of several lantern slides. Considerable discussion followed the paper.

"*The Properties of British Fireclays suitable for Glass Works Use.* Part I. *The Variation of Shrinkage, Density, and Porosity with Temperature.*" (Preliminary communication). By Edith M. Firth, B.Sc., F. W. Holden, B.Sc., and W. E. S. Turner, D.Sc.

This paper was well illustrated by assemblies of fireclay blocks showing the behaviour of various fireclays under the tests outlined by the authors. The paper is the first communication of a research carried out under the auspices of the Refractories Research Committee of the Society.

"*The Examination of Optical Glass in Relation to Weathering Properties.*" By A. V. Elsden, Oswald Roberts, and H. S. Jones.

This was taken as read, and will be published in the *Journal* of the Society in due course.

The above meeting ended the session.

The first meeting of the new session will take place during October.

MINERALOGICAL SOCIETY.

Ordinary Meeting, June 17, 1919.

Dr. A. E. H. Tutton, F.R.S., Past President, in the Chair.

"*Diamonds from the Gold Coast.*" By A. E. Kitson.

The crystals and their occurrence were described.

"*Andalusite (Chiastolite); its Genesis, Morphology, and Inclusions.*" By A. Brammall.

In a survey of thermometamorphic "spotted" rocks evidence based on structural features, optical properties, and microchemical reactions is adduced to show that certain types of spots convergent towards such minerals as chiastolite, andalusite, cordierite, mica, and chloritoid record arrested development, and that they are probably ontogenetically related. The spot is a complex system containing a volatile phase, water, and its development involves metamorphic diffusion and differentiation controlled by changing conditions of temperature and stress, tendency being towards the attainment of an equilibrium end-point in a metastable mineral. Thermal and stress conditions adequate to initiate the tendency may be inadequate to sustain it, the time factor also being involved; development may be arrested and abortive effort recorded as a mineral "spot," the nature of which is determinable, but is often vague or wholly conjectural. The chemical and physical characters of argillaceous sediments are considered with special reference to the genesis of chiastolite. Clays contain a high proportion of hydrated silicates of alumina readily soluble and in part probably colloidal. On rise of temperature diffusion effects the segregation of the primary clot; diffusion inwards of allied molecules and diffusion outwards of alien substances tend to promote homogeneity and reconstitution within the spot, the peripheral zone being maintained for a time in a relatively high state of hydration. In this connection the peripheral zone of yellow-brown non-pleochroic, and isotropic stain is significant; microchemical tests show that it is due to ferric hydrates, which are known to be liable to spontaneous dehydration, and it is suggested that the ferric hydrate in the peripheral stain acts as a catalyst assisting dehydration within the spot and transmitting water to the base. For chiastolite (andalusite) a mechanism of formation is suggested to cover the observed facts, to explain the characteristic distribution of its opaque inclusions, and to account for crystals which have the superficial aspect of cruciform twins.

"*The Mineral Composition of Oolitic Ironstones.*" By R. H. Rastall.

In many oolitic ironstones the ooliths contain more iron or are more highly oxidised than the matrix. Assuming that the iron content of such rocks is introduced by metasomatism of calcium carbonate this may be explained in the following way:—Many ooliths and organic fragments in limestones consist of aragonite, while the cement is calcite. Aragonite is less stable than calcite and more readily decomposed by iron-bearing solutions, which therefore attack the aragonite first, while the calcite is replaced later. Hence we have the following scheme in successive stages:—

Ooliths,	aragonite →	chalybite →	limonite.
Matrix,	calcite →	calcite →	chalybite.

The ooliths are always a stage ahead of the matrix replacement and oxidation. The origin of the green silicate of iron, found in many ironstones, requires further investigation.

Eighth List of Mineral Names. By L. J. Spencer.

INSTITUTION OF MINING AND METALLURGY.

Ordinary Meeting, June 19, 1919.

Mr. H. K. Pickard, President, in the Chair.

"*The Genesis of Igneous Ore Deposits.*" By W. H. Goodchild.

The primary object of this paper is to provoke discussion. Its scope is limited to the synoptic presentation of a few of the more important principles and processes concerned in the formation of ore deposits from rock magmas, together with an outline of sundry more or less novel methods for elucidating the nature of those processes. Starting out with the fundamental principle that "the meaning of a vast number of the structures with which the geologist is confronted—either in the field on the grand scale, or in the laboratory with his small specimens—cannot, as a rule, be correctly gauged without some considerable knowledge of the various physico-chemical equilibria within the masses at various stages of the general cooling process," the author proceeds to enunciate four leading principles as laid down by Le Chatelier, van 't Hoff, Ostwald, and Henry as a basis for calculating the general characters and directions of the chemical changes occurring during the cooling. He then deals with the volume relationships of minerals and the problem of volcanic power, the evolution of igneous rocks by magmatic differentiation, and the formation and behaviour of submagmas, from which he goes on to classify igneous ore deposits under three types, namely, those due to precipitation concentration, solution concentration, and a third group which appear to arise from the degasification of enriched subsidiary magmatic differentiates, this latter class not improbably including the metallic copper of the Lake Superior region and the gold deposits of the Rand. The author's endeavour is, however, rather to illustrate a method of attack on some of the problems than to discuss in detail any particular deposits, and he urges a more extended practice of what he terms Magmatic Geology as a means to that end.

We have received the following from a correspondent:—I believe there is a big demand for "dolomite," and a quarry has just been started in Derbyshire. I am testing some property for yellow ochre, and near by there is a good quantity of "dolomite." It is mostly laminated and florid. If you could put me in touch with a market for same I should be most grateful to you.

NOTICES OF BOOKS.

The Chemists' Year Book, 1918-1919. Edited by F. W. Atack, M.Sc.Tech. (Manch.), B.Sc. (Lond.), Fellow of the Institute of Chemistry. Assisted by L. Whinyates, Assoc.M.S.T. London: Sherratt and Hughes. Manchester: 34, Cross Street. 1919. In two Volumes, price 15s. net.

The editor regrets that the present edition has been delayed on account of labour difficulties, a trouble that all who are in any way connected with the publishing trade know is unavoidable. The delay is not so serious as it would have been under normal conditions, for although strenuous efforts have been made in chemical and other circles since November last to lose no time in getting to work, there has been a weight on the minds and efforts of all men that could not be lifted until peace had been signed.

Happily this has now come to pass and there is every prospect of a period of unfettered labour.

The new edition of the Year Book will be welcomed by all chemists, and the editor appears to have spared no effort to make the work as useful as possible.

In the list of the contributors of new and revised sections we note the names of some of the most prominent men in the profession.

The book is bound in two volumes on thin paper with thin covers that can be easily carried, and is numbered consecutively, occupying 1146 pages. Vol. I. opens with a table of atomic weight determinations for 1917, and gives the usual chemical data, a complete system of qualitative analysis, volumetric, electro-chemical, and spectrum analysis; this latter section contains a useful plate showing the absorption spectra of a large number of dye-stuffs from Wood's "Physical Optics," and the volume ends with "Useful Memoranda," which includes practically all the arithmetical and tabular matter that are needed in the chemical laboratory.

Vol. II. opens with a list of notable dates in the history of chemistry from 640 B.C. to A.D. 1905! A glance through the list brings out the fact that the discoveries in chemistry have been very widely distributed, and it is doubtful if any country can claim pre-eminence.

This volume contains the physical constants, densities, vapour-pressures, boiling- and melting-points, and other like data, which is followed by a very good chapter on "Crystallography" contributed by E. H. Rodd, D.Sc., and other articles on important branches of industrial chemistry, dye-stuffs, and photography.

The index is very complete, and enables one to turn to any item of the eleven hundred odd pages with minimum labour.

On the whole the Year Book is one that no working chemist can afford to do without, and the authors are to be congratulated upon having compressed so much useful information into such small compass.

Tables of Productive Indices. Vol. I. *Essential Oils.* Compiled by R. Kanthack. Edited by Dr. J. N. Goldsmith. Londod: Adam Hilger, Ltd. 1918. Pp. 148. Price 15s. net.

The publishers of this book intend to issue a series of tables of refractive indices of technical products, this first volume dealing with the essential oils. The oils are arranged in alphabetical order, their botanical origin being stated in each case and their refractive indices tabulated, a special point beidg made of providing exact data as to the temperature at which the determination was made. It is quite rightly been pointed out that a mere statement of the index with no information as to the temperature at which it was taken is often misleading and worse than useless, and if no temperature is given in the original paper the data obtained are ignored. A very useful list of references is given, and the limits between which the results obtained with genuine samples may lie are often stated. Schimmel's average correction per degree of temperature is adopted. The book is interleaved with blank pages for notes, and the printing is exceedingly clear and good.

NOTES.

New Yellow Dye and Light—Filters made from it.—(Note from the Research Laboratory of the Eastman Kodak Co., by C. E. K. Mess and H. T. Clarke, published in *British Journ. Photog.*, 1919, p. 48).—The dyes previously used for making light filters were principally picric acid, tartrazine, and filter yellow. Picric acid, while having a satisfactory absorption, is unstable and as a consequence the early gelatin filters were made chiefly with tartrazine, which is quite stable. Tartrazine, however, has the disadvantage that it transmits the ultra-violet and that filters made from it are relatively inefficient. The introduction of filter yellow in 1907 supplied a dye having a good absorption in the ultra-violet, reasonably sharp cut in the spectrum and great stability. It was still desirable for high efficiency, especially in filters for aerial photography, that a dye should be obtained possessing the stability and ultra-violet absorption of Filter Yellow but with greater sharpness of cut. The compounds of phenyl hydrazine with sugars are yellow in colour, and a soluble compound of this type has been prepared by coupling glucose with parahydrazine-benzoic acid. The sodium salt of glucose-phenyl-osazone-para-carboxylic acid prepared in this way, proving to be a very suitable dye for the preparation of sharp cut light filters, has been given the name of "Eastman Yellow." From this new dye light filters have been prepared under the designation of EK-1 and EK-2 filters, which are stable to light, have a very strong absorption for ultra-violet, and are considerably sharper and more efficient than K filters made from filter yellow.—*Journ. Franklin Institute*, May, 1919.

Mr. B. W. J. Warren, in a paper appearing in the current number of the *Analyst*, gives the following method for the estimation of lead in foodstuffs:—"Ten grms. of foodstuff are incinerated in a silica dish, dissolved in a small quantity of water with the addition of 1 cc. of nitric acid, filtered, and washed. To the filtrate, which should be colourless, a slight excess of ammonia is added, the precipitate filtered and washed well. (The filtrate can be tested by the B. P. method). The copper will be in the solution, while the lead (most if not all) will be in the precipitate. The precipitate is washed into a Nessler cylinder with water, 5 cc. of dilute acetic acid are added, followed by an aqueous solution of hydrogen sulphide, and the colour matched in the usual manner."

Soldering Aluminium.—Two pieces of aluminium may be united by soldering or brazing. For soldering, the surfaces must be rubbed down with emery paper with a small quantity of vaseline. The flux may be made up as follows, according to a prescription given by the Soldering Association:—Lithium chloride, 15 per cent; potassium chloride, 45 per cent; sodium chloride, 30 per cent; potassium fluoride, 7 per cent; bisulphate of soda, 3 per cent. The joint should be carefully brushed and washed in hot water to remove all traces of the flux. For brazing, metals such as tin, bismuth, cadmium may be used. The process should, however, be used only in exceptional cases. —*Revue Générale de l'Electricité*, May 3, 1919.

The Right Hon. Lord Weir of Eastwood has promised to open the Shipping, Engineering, and Machinery Exhibition at Olympia on September 25 next. This Exhibition, of which Sir Owen Philipps, G.C.M.G., M.P., is Hon. President, Sir Archibald Denny, Bart., Chairman of the Committee of Experts, and Mr. F. W. Bridges, Secretary and Organising Manager, and which was to have been held in the autumn of 1914, but in common with other

important events had to be postponed on account of the War, will afford the general public an opportunity of becoming acquainted with the luxury, comfort, and ease of present-day sea travel. The interval which has since elapsed has, moreover, afforded British Engineers an opportunity of introducing vast improvements in connection with Marine and General Engineering, with the result that Olympia will be full to overflowing with machinery and appliances of intense interest to all concerned with the shipping, shipbuilding, and engineering industry, and the exclusion of everything of enemy origin will enable the British public to see how absolutely independent we can be of anything produced in enemy countries, at any rate as regards this particular industry. The Exhibition is to remain open for three weeks.

AN interesting paper by Ernest Oertly and Rollin G. Myers on "A New Theory relating Constitution to Taste," appears in the *Journal of the American Chemical Society* for June, 1919. The authors review the work that has been done on this subject and introduce some new ideas. They consider that the sweet taste of a given compound is due to two distinct factors, a glucophore and an auxogluc. They define the glucophore as a group of atoms which has the power to form sweet compounds by uniting with a number of otherwise tasteless atoms or radicals, and an auxogluc as an atom or radical which combined with any of the glucophores yields a sweet compound. Examples of these compounds are named and a very complete list of taste trials of organic compounds is given.

THE COMMERCIAL PRODUCTION OF HELIUM.—One of the remarkable achievements during the war has been the production of helium in quantities sufficient for the inflation of dirigibles. The lifting force of helium is said to be 92 per cent of that of hydrogen, and it has the very great advantage that it is not inflammable; the diffusion losses are also less than those of hydrogen. Some natural gases in Canada were found to contain about one-third per cent of helium, and the gas has also been obtained from other like sources; great quantities of the gas were at hand when hostilities ceased and plants for its rapid accumulation were under construction. As the dirigible is likely to be of considerable value for many purposes in the near future the labour expended upon the subject is not likely to be lost.

MAJOR THEODORE W. STILL, as United States representative on the Inter-Allied Commission, after a visit to the German Chemical Factories in the occupied territories, is of the opinion that, considering the advantage gained in America by the last four years of experience in chemical manufacturing and the lessons learned by our equipment manufacturers, the German plants at the present time from an equipment standpoint and general layout are not superior to the existing American development, their advantage being that they have an experienced and long-trained *personnel* schooled and willing to carry on the laborious details; but if our people here at home will encourage our new, rapidly growing industries, there is no reason why our own *personnel* cannot equal or, in fact, surpass that of the Germans. Among the developments to be noted during the war in Germany which are of special interest is the production of synthetic rubber on a large scale and a practical basis. This has been done at the Bayer plant in Leverkusen, and the production, though very expensive, was of material assistance in meeting their great shortage of rubber.

THE Department of Commerce of the Bureau of Standards, Washington, have recently issued a publication entitled "Aluminium and its Light Alloys." The physical properties of aluminium and its alloys are very exhaustively discussed; the data collected together cannot fail to be of value to any interested in manufactures where aluminium is used, and the authorities deserve great thanks for placing the publication at the disposal of any who address a request to the Bureau of Standards, Washington, U.S.A.

NOTES FROM FOREIGN SOURCES.

Oil of Fenugreek.—H. E. Wunschendorff.—The seeds of fenugreek contain about 7 per cent of a golden-yellow oil, having a very characteristic and disagreeable smell and taste. The oil belongs to the group of drying oils; it does not give the elaidine reaction; when a thin layer of it is spread on glass it rapidly solidifies and the golden-yellow varnish thus obtained is not soluble in ether. The oil dissolves in all proportions in ether, benzine, carbon disulphide, and petroleum ether. Absolute alcohol in the cold dissolves only one part in 20, and larger quantities on warming. Acetone dissolves it incompletely. The density of the oil at 15° is 0·9471 and the index of refraction at 22° is 1·4774. The saponification and iodine indices are 189·5 and 137·8 respectively. The oil contains 92·9 per cent solid fatty acids and 1·50 per cent volatile fatty acids. Lecithine is present in it in the proportion of 6·25 per cent and phytosterine in the proportion of 0·5 per cent. The fatty acids present are chiefly linoleic and palmitic, with much smaller quantities of linolenic and oleic.—*Journ. de Pharmacie et de Chim.*, 1919, xix., 397.

Determination of Lactose and Albuminoids in Milk heated in an Autoclave, and in Milk Preserved by the Addition of Potassium Bichromate.—Pierre Defrance. —The author has already shown that when milk preserved with potassium bichromate is analysed, after a month to six weeks the total quantity of albuminoids remains unaltered, while the amount of true casein shows a very decided decrease. They now propose to investigate the nature of the decomposition products to ascertain whether they are optically active and lævorotatory. It would also be interesting to determine the total albuminoids and the true casein in milk heated with or without sodium bicarbonate, and to see if there is in this case any diminution n the amount of true casein, and the author intends to investigate this question.—*Annales des Falsifications*, 1919, icxxv.-cxxvi., 78.

Cryoscopic Study of Couples.—Cadmium Bromide and Alkali Bromide, Cadmium Chloride and Alkali Chloride.—E. Cornec and G. Urbain.—The authors have studied the couples formed by cadmium bromide and chloride with alkali bromides and chlorides, and have proved the existence of salts of the type 1 : 2, which are generally hydrated, in the case of the bromides. There are indications also of compounds 1 : 1 and 1 : 4 for potassium, and 1 : 1 for sodium. In the case of the chlorides, the double salts are of the type 1 : 1. The cryoscopic method not only shows the formation of double salts in solution when solutions of simple salts are mixed, but also, at any rate in the case of simple salts, indicates the nature of the double salts in equilibrium with their constituents in the solutions. Compounds like $CdI_2.2HI$, which cannot be isolated on account of their instability, may also be detected thus.—*Bull. Soc. Chim. de France*, 1919, xxv.-xxvi., 215.

New Method of Preparing Complex Compounds of Platinum and its Analogues.—L. Tschugaeff.—It is known that certain elementary atoms or atomic groups possess an exceptional tendency to enter into direct union with the central metallic atom of the complex molecule of which they form a part. This is the case, for example, with iodine, the nitro and oxalate groups in the complexes which cobalt, platinum, and a series of other heavy metals yield with ammonia, amines, organic sulphides, and other more or less basic substances. Cleve first employed this remarkable fact to prepare platinous compounds of general formula $[Pt.2a.I_2]$, and by an analogous method the author, in collaboration with M. Lebedinski, obtained a new rhodium compound $[Rh.3a.X_3]$ belonging to a non-electrolyte type in which the chloride and oxalate group were completely masked. Later researches have shown that the same fundamental principle can be employed in working out a very convenient method of preparing com-

plexes, especially in dealing with compounds belonging to lower types. The method depends upon the fact that in the reactions which take place between soluble platonitrites or iodoplatinites and ammonia or organic amines the first molecules of the ammonia, &c., are fixed much more rapidly than the later molecules. Thus when the derivative $[Pt.2NH_3.(NO_2)_2]$ is heated with NH_3 one other molecule of ammonia can be fixed giving $(Pt.3NH_3NO_2]NO_2$, but it is only by prolonged heating with a large excess of ammonia that the fourth molecule of NH_3 can be fixed, giving $[Pt.4NH_3](NO_2)_2$. Thanks to this difference in the velocity the reaction can be arrested at any desired stage and the product thus obtained is always practically pure. To prepare the derivative $[Pt.2NH_3.I_2]$ the author has first made a solution of iodoplatinite by heating K_2PtCl_4 with potassium iodide in aqueous solution, then adding ammonia and heating to boiling. The nearly black liquid rapidly clears, and an abundant yellowish brown precipitate is deposited. The same method can be used to prepare certain complex compounds of rhodium corresponding to lower types which are not much known at present. Thus the non-electroyte $Rh.3NH_3I_3$ can be obtained by heating rhodium iodide with aqueous ammonia in excess, the reaction being favoured by the presence of potassium iodide in the solution.—*Bull. Soc. Chim. de France*, 1919, xxv.-xxvi., 234.

NOTES AND QUERIES.

The Intravenous Products Company, Thirty-eighth and Wazee Streets, Denver, U.S.A., ask for quotations for cacodylate of soda and the names of manufacturers of cacodylic acid; also prices of barium oxide in one ton lots.

Assistant Metallurgical Chemist (21) requires Situation. Experience in both Ferrous and Non-ferrous Analyses, Case-hardening, Heat Treatment, Mechanical Testing, and Metallography.—Address, A. M. C., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Assistant Chemist wanted, 25 to 35 years of age. Applicant must have had thoroughly good training. Work principally Analytical with Precious and Non-ferrous Metals. State full particulars as to age, qualifications, experience, and salary required to Managing Director, The Sheffield Smelting Co., Ltd., Sheffield.

Celluloid Chemist, with several years' practical experience in Celluloid manufacture, required for important position in charge. First rate salary and prospects.—Address, C. W. L., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C 4.

Chemist, three years' experience in large Tar Products Works before taking active service, now demobilised, desires Employment in London or the Provinces.—Address, T. T., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted to Apprentice to Analytical Chemist, youth aged 18. Just sat for Matric. State terms.—Address, "Apprentice," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Youth (17), good knowledge of Chemistry, seeks Employment in Laboratory.—Address, A. H., 1, Phœnix Lodge Mansions, Hammersmith, W.

CHEMICAL BENCH wanted. Suitable for student's small private laboratory.—Address, C. B., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

BIRKBECK COLLEGE, LONDON.

ASSISTANT LECTURER IN CHEMISTRY.

The Governing Body invite applications for the above appointment. Commencing salary £220 to £250 (according to experience and qualifications), rising to £400, with temporary war bonus of £39.

Applications (by JULY 14) to THE SECRETARY, Birkbeck College, E.C. 4, from whom further particulars may be obtained.

BATTERSEA POLYTECHNIC,

LONDON, S.W. 11.

The Governing Body invite applications for the Appointment of FULL TIME ASSISTANT LECTURER IN CHEMISTRY, with Honours Degree, and experience in Chemical Engineering. Commencing salary £300, rising to £400, with temporary war bonus of £39.

For particulars of the appointment send stamped addressed envelope to the SECRETARY.

ARMSTRONG COLLEGE, NEWCASTLE-UPON-TYNE.

DEPARTMENT OF CHEMISTRY.

The Council invites applications for the CHAIR OF CHEMISTRY. Salary commencing at £600 per annum.

The Council also invites applications for the Posts of two ASSISTANT LECTURERS AND DEMONSTRATORS. The salary in each case will commence at £200 per annum, and the appointments will be, in the first instance, for three years. At the end of this period the Assistant Lecturers will be eligible for promotion to Lectureships.

Candidates are requested to send five copies of their applications and of not more than three testimonials, so as to reach the SECRETARY, Armstrong College, not later than JULY 19, 1919.

BIRMINGHAM MUNICIPAL TECHNICAL SCHOOL.

Applications are invited for the following LECTURESHIPS. In addition to the salary indicated, there is at the present time a War allowance of £78 per annum.

1. CHEMISTRY. Salary £300 to £450.
2. CHEMISTRY. Salary £250 to £380.
3. METALLURGY. Salary £250 to £450.

The commencing salary will be dependent upon the experience of the applicant. Full particulars may be obtained on application to the SECRETARY, Municipal Technical School, Suffolk Street, Birmingham.

RUTHERFORD TECHNICAL COLLEGE, NEWCASTLE-UPON-TYNE.

Principal—Mr. C. L. ECLAIR-HEATH, Wh.Sc., A.M.I.M.E.

The Newcastle-upon-Tyne Education Committee invites applications for the Appointment of CHIEF LECTURER IN CHEMISTRY from gentlemen who possess the following qualifications:—

(a) Works and Laboratory experience in the Chemical industry.
(b) Good training at a University or Technical College in Chemistry and cognate subjects.
(c) A degree or its equivalent.

Commencing salary £350 per annum.

Applications, in the candidate's own handwriting, on forms which may be obtained from the undersigned, must be returned not later than JULY 12, 1919.

PERCIVAL SHARP,
Education Offices, Director of Education.
Northumberland Road, Newcastle-upon-Tyne.

SWANSEA TECHNICAL COLLEGE.

Principal—W. MANSERGH VARLEY, M.A., D.Sc., Ph.D.

LECTURER IN PHARMACY.

Applications are invited for the Appointment of a LECTURER IN PHARMACY at the above College.

The duties will include the charge of all Pharmaceutical Classes, including Pharmacy, Materia Medica, and Botany, required for the Examinations of the Pharmaceutical Society.

Salary £350.

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T. J. REES, B.A.,
Education Offices, Director of Education.
Dynevor Place, Swansea, June 26, 1919.

THE CHEMICAL NEWS

VOL. CXIX. No. 3091.

THE GLASS-MAKING INDUSTRY.

IN a paper entitled "Glass-making Before and During the War," Mr. Harry J. Powell, who for the past forty-five years has carried on glass manufacture at the Whitefriars Glass Works, gave an interesting *résumé* of his experiences of glass-making. The perfection in glass work that has been reached by the firm, and the high position that they hold in the spheres of art, ornamental, and scientific glass-ware, renders anything that Mr. Harry Powell has to say upon the subject of special interest and importance. The author opened with an account of the "toughened" glass of M. de la Bastie, a manufacture about which the Press of the day indulged in some very wild speculations. Mr. Powell at the time of the discovery of the process some forty-four years ago exhibited at the Society of Arts some specimen tumblers toughened by the inventor's method. Much interest was shown at the rough usage that they would stand without breaking; when, however, they did break it was more in the nature of an explosion than that of an ordinary fracture. Mr. Powell was sceptical of the practical value of the process from the first, and we know now that his doubts were justified.

A very interesting history was given of the glass-making industry in London; there is a continuous record for over 300 years. In 1696 there were no less than 24 glass-houses in the London district; there were glass-works in Blackfriars in 1606. The Whitefriars glass-house is mentioned in the *Tatler* of August, 1710. Passing on to the period just before the war the author drew a very sombre picture of the state of English glass-making; speaking generally, there was little or no attempt to study glass-making from the scientific standpoint, except in the isolated case of Messrs. Chance Bros., who "with difficulty kept alive the manufacture of optical glass." The scientific manufacture of glass was rapidly becoming a German monopoly.

For all that, individual glass-makers in England were always on the alert to devise new material to meet the various demands of industry. The Whitefriars Glass Works furnish a list that shows that in a quiet unobtrusive way they were doing an immense amount of laborious research. The following items are selected from the list of special glasses recently made:—Many kinds of "Crookes" glasses for spectacles, didymium glass for signal purposes, glass for Lord Berkeley's researches in electrolysis, glasses with special electrical properties, Dewar's flasks glass for thermometers, soda-glass for X-ray bulbs, and uranium glass.

The needs of the war and the cutting off of supplies from Germany caused very considerable activity in the glass-making industry, and the labours of Prof. Sir Herbert Jackson and others has resulted in the issue by the Institute of Chemistry of formulæ for many pre-war German glasses.

During the war immense quantities of soda-lime alumina glass was made at Whitefriars for mine-horns, some six hundred thousand of these having been constructed by the Hyposol Company, of Harrow Wealdstone.

Mr. Powell was able to give a very gratifying list of the special glass manufactures undertaken by other glass makers during the war.

The probable increased employment of automatic machinery in the manufacture of glass-ware and the effect it would have upon the industry was next discussed, and the paper concludes with some valuable remarks upon artistic hand-made productions, an art in which the firm of Powell and Sons excel.

Mr. Powell enjoys the distinction of being an expert in elegant design and is also thoroughly acquainted with the technical branch of art glass work. Referring to a proposal that has been made that industrial designers should be trained at some central institution and sent out "to reform and enlighten the benighted glass manufacturers," he gave some very sound advice, suggesting that it would be wise for the would-be designer to first study in a glass house the nature of glass and how vessels are made; right design for glass is only possible when the properties and working methods are taken into consideration.

In conclusion, referring to the future prospects of the British glass industry, attention was drawn to the recent attempt to obtain Government permission for unrestricted importation of glass-ware from abroad; if this is allowed there is little hope of the survival of the British glass industry.

BENZIDINE STANNICHLORIDE.

By EDWARD BARNES, B.Sc. (Lond.).

AZOBENZENE is reduced to benzidine by boiling with $SnCl_2$ in HCl. After performing this reduction, in the course of a piece of work, it was noticed that on cooling short silky needles separated from the resulting solution. These needles were found to contain both tin and benzidine. After purification, analysis gave 22·7 per cent Sn, 41·0 per cent Cl, and 5·4 per cent N. This shows that the substance has the composition $NH_2C_6H_4.C_6H_4NH_2,H_2SnCl_6$, the values for which are 23·0 per cent Sn, 41·1 per cent Cl, and 5·4 per cent N. A series of stannichlorides of organic bases has recently been described by Druce, but benzidine was not one of the bases used by him (CHEMICAL NEWS, cxviii., 1.). Benzidine stannichloride is readily soluble in warm water, but much less so in cold. It appears to be considerably hydrolysed when dissolved in water or dilute HCl, for a solution containing equivalents of benzidine hydrochloride and stannic chloride gives crystals on evaporation containing only a little tin, while with two $SnCl_4$ molecules to one of base a deposit containing only about 10 per cent of tin is obtained. In the presence of a considerable excess of $SnCl_4$, however, the body deposited has the above composition. The following was found to be a good method of obtaining this salt:—4·5 grms. of benzidine, 50 cc. of water, and 5 cc. of strong HCl are heated together till a clear solution is obtained, and then 26 grms. of $SnCl_4$ (anhydrous), dissolved in a little water, is added. A deposition of crystals soon begins. When cold, the substance is filtered off and dried in a desiccator over potash. It consists of colourless needles, which are stable in dry air at ordinary temperatures but which evolves HCl and $SnCl_4$ on heating to 100° C.

Double Salt of Benzidine Hydrochloride and Mercuric Chloride.—During the preliminary examination of the product of the reduction of azobenzene by acid stannous chloride, above described, $HgCl_2$ was added to its solution to test for stannous chloride. Instead of the white amorphous precipitate of Hg_2Cl_2, a precipitation of white needles occurred. This precipitate was found to contain both benzidine and mercury but not tin. The percentage or mercury in the precipitate was found to vary somewhat with the conditions under which it was formed, but after recrystallisation from dilute HCl the following values were obtained:—38·1 per cent Hg, 26·9 per cent Cl, and 5·5 per cent N. These values indicate that the composition of the substance is $NH_2C_6H_4.C_6H_4NH_2,2HCl,HgCl_2$. The calculated values for this composition are 38·0 per cent Hg, 26·9 per cent Cl, and 5·3 per cent N. The compound may by prepared by mixing hot solutions containing one equivalent each of mercuric chloride and benzidine hydrochloride. The body separates on cooling as long transparent blades. The compound is slightly soluble in cold dilute HCl and readily so in hot. Pure water turns

it yellow, probably causing partial hydration. The yellow product is only slightly soluble in water, even on boiling. A very small quantity of HCl, however, causes it to dissolve readily.

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IS THE ELECTRICAL CONDUCTIVITY OF THE ELEMENTS CONDITIONED BY THE PRESENCE OF ISOTOPES?

By F. H. LORING.

Silver, whether taken at its fusion-point (liquid) or at ordinary temperatures, has a higher electrical conductivity than any other element under similar conditions. Mercury in a solid state has a much higher conductivity than when liquid. Generally speaking, all metallic elements would have an infinite conductivity at or close to the absolute zero temperature, whereas the semi-metallic and non-metallic elements would become poorer conductors or even better insulators at low temperatures. These are, of course, well known facts. Conductivity is therefore profoundly modified by temperature, and the question arises—Can it be conditioned to a similar extent by any other cause?

When comparing the conductivities of different substances, their physical states due to the temperature, &c., should be taken into account; and while it is not possible to make the comparisons when the states are on the average brought to the nearest point of coincidence—owing to lack of experimental data—there is generally sufficient information available to enable the different substances to be arranged in the order they would follow should the comparisons be made under such conditions.

At ordinary temperatures bromine is a liquid, and being non-metallic it has a very high resistance; it is an insulator, in fact, with a dielectric constant of 3, paraffin-wax being about 2, while selenium is about 6. Ice at -2° C. has a dielectric constant approaching to 100, but probably conduction sets in at this temperature. At -200° C. the constant becomes 2·5, while pure water may be taken as about 80 at room temperatures.

Non-metallic combinations afford a weaker class of conductors, as instanced by nitric acid when dissolved in water in the proportion by weight 31 per cent acid to 69 per cent of water. This is a maximum-conductivity solution which has a higher conductivity than other solutions containing salts of metals; in fact, it is the best liquid conductor known of the electrolytic class, the specific conductivity being 0·782 in ohms^{-1} cm.^{-1} at 18° C.

If it be assumed that silver is made up of isotopes having atomic masses 107 and 111 in the respective proportions 7 to 2, which gives the mean atomic mass of 107·888, then there would be 22·2 per cent of the higher mass atoms calculated by taking the relative numbers 7 and 2, or 22·8 per cent by taking corresponding aggregates. In the same way, bromine, assumed to have isotopic atoms of masses 79 and 80 in respective proportions 1 to 13, would yield corresponding percentages 92·8 and 92·9, the mean atomic mass of this element being 79·928 on the assumption of these isotopes in the porportion indicated.

Taking these two extremes it would appear that the higher the percentage of higher atomic mass isotopes the lower the electrical conductivity, since silver is the best conductor and bromine is an insulator. Therefore, electrical conductivity might be conditioned by the proportion of isotopes present.

From the accompanying table it will be seen that the rule holds good for the elements having isotopes of such values and in such relative proportions as to make up the present accepted atomic masses. While the suppositions involved are self-supporting a note of caution is necessary, since the probability of arriving at a true representation of facts is not necessarily strengthened by the concidence of two or more hypotheses being in mutual agreement. With a small balance of probability in favour of a given hypothesis, one may attempt to work out the consequences with a view of finding some related property which will throw light upon the subject under investigation.

From the rule in question, the conductivity should be very low when the lower or higher atomic mass isotopes are absent, as would appear to be the case with regard to H, He, C, O, N, and F, all atoms of such elements being whole numbers and those of each element alike in mass.

It is generally believed that the isotopes of radio-active change are electrically equal if they are of the same atomic number, and consequently occupy the same group-place in the periodic table. The atomic number is supposed to represent the magnitude of the nuclear positive charge. Why, then, should the mass variation in any way modify the conductivity? Or, as radium, probably a conducting element (being a pronounced metal), changes into an inert gas by the loss of one helium atom for each radium atom disintegrating, the inert element should itself be a conductor in the liquid or solid states, since the isotopic proportion should be the same in both elements, assuming dual species as suggested in the case of silver for example. Whether the condensed emanation which as a solid glows like a tiny arc lamp (to use Ramsay's description of its behaviour when frozen with liquid air) is a proper conductor or not is unknown. In the solid state the emanation is not transparent; but, on the other hand, it has no metallic properties so far as is known.

According to E. Bouty (*Comptes Rendus*, cl., 149) the dielectric cohesion of neon is less than that of helium, and it is therefore the lowest so far known. Discharges pass through neon so readily that the small potential difference produced by passing it from one vessel to another is sufficient to make it glow, and in pumping operations it exhibits a fire-like appearance. This is perhaps worthy of note, because neon appears to have isotopes according to J. J. Thomson's positive-ray experiments, but confirmation of this atomic duality is considered necessary.

From the values given in the table it would seem that whether the conductivity increases or decreases with temperature it might depend upon the isotopic proportion; so that from antimony, which has over 50 per cent large-mass isotopes, to bromine the resistance temperature coefficient should be negative, but the physical state of the element introduces complications.

The behaviour of alloys in not exhibiting the change of resistance with temperature as expected might be explained by the solid solutions of different metals having atomic masses which would give the differential effect, the respective metals acting as if they were isotopes from the electrical point of view. Lead from different sources and having presumably different proportionate numbers of isotopes should have slightly varying electrical conductivities according to these views.

The difference in mass (i) between the isotopes of a given element (a difference of, for example, 1, 2, or 4), the percentage (p) of higher mass isotopes as given in the table, and the decimal fraction of the mean mass (f) are of necessity related as shown by the equation—

$$p = \frac{(f+n) \times 100}{i} \qquad n = 0, 1, 2, 3, \text{ or } 4.$$

The only known means of direct separation and mass measurement of atoms is the positive-ray method of Sir J. J. Thomson; but unfortunately rays are only obtainable from the gaseous or volatile elements, and those atoms nearly alike in mass would not be distinguishable photographically. Mercury is slightly volatile at low temperatures, but the lines on the plate are not sharp enough to distinguish between mass values of 199 and 203, especially if by any chance the assumed heavier atoms carry the even charges (see Chemical News, 1914, cx., 25). Improvements, however, in the positive-ray method may be expected.

Element.	(A). Atomic mass.	(B). Mean mass of isotopes.	(C). Mass of isotopes.	(D). Proportionate number of isotopes and percentages of higher values.	(E). Volume Res. × 10—6. At 18° C.	(F). Just above m. p. (liquid).	(G). Just below m. p. (solid).	Di-electric const.	Remarks.
Cu	63·57	63·50	63 67	7 1 = 12·5 p.c.	1·78	21·6	10·9		This element is a better conductor than Ag below −70° C. (Niccolai, *Acc. Lincei*, 1907, xvi., 906).
Ag	107·88	107·88	107 111	7 2 = 22·2 p.c.	1·66	16·2	9·32		The at. wt. of Ag is very accurately determined, but the 3rd decimal figure is not accurately known.
Au	197·2	197·20	196 200	7 3 = 30·0 p.c.	2·42				F & G not determd. by Tsutsumi, but probably same increase as Ag, 12·7 solid, 30·4 liquid (Northrup).
Zn	65·37	65·33	64 68	6 3 = 33·3 p.c.	6·1	36·2	17·3		
Cd	112·40	112·45	111 115	7 4 = 36·3 p.c.	7·54				See Northrup (*Jn. Frank. Inst.*, June, 1915, pp. 621-662) *re* conductivity of Zn and Cd.
Hg	200·6	200·54	199 203	8 5 = 38·5 p.c.	95·6	93·8	29·2		
Sb	120·2	120·18	119 121	7 10 = 58·9 p.c.	40·5	108·0	162·0		
Ge	72·5	72·27	71 43	4 7 = 63·6 p.c.	h.				F and G not known.
As	74·96	75·00	72 76	3 9 = 75·0 p.c.	h.				F and G not known.
Se	79·2	79·23	75 80	2 11 = 84·7 p.c.	v. h.			6	
I	126·92	126·92	126 127	1 12 = 92·4 p.c.	v. h.			4	
Br	79·92	79·93	79 80	1 13 = 92·8 p.c.	v. h.			3	

(A). Atomic Weights, 1918.

(B, C, D). See CHEMICAL NEWS, 1914, cix., pp. 143, 169, 241; 1915, cxi., p. 13; 1919, cxviii., p. 145, Section 25.

(E). Kay and Laby, "Tables of Phys. and Chem. Constants."

(F, G). H. Tsutsumi, *Sci. Repts. Tohoku Imp. Univ.*, Sept., 1918, vii., p. 93. See also investigations of E. F. Northrup, Vincentini, and others. C. Hering in *Met. and Chem. Eng.*, Jan., 1915, p. 23, gives temperature curves of resistivities compiled from available data.

(NOTE.—The resistance of practically all dielectrics decreases with rise of temperature, and the dielectric capacity bears no simple relation to dielectric resistance).

For a discussion on the possibility of separating isotopes, see F. A. Lindeman and F. W. Aston in the *Philosophical Magazine* for May, 1919, 523. In this paper it is suggested that theoretically different isotopic atoms are separable, but practically the difficulties are exceedingly great, the various methods considered being—

1. Fractional distillation.
2. Diffusion or effusion.
3. Gravitation.
4. Centrifugal separation.
5. Electrical method of positive rays.

The electrical method yields only microscopic quantities, and thus far it has a limited application, as, for example, no lead isotopes, or indeed lead atoms at all, can be projected and photographed. The centrifugal method is regarded as the most promising.

I have carried out experiments on pulverised materials by subjecting them to the impelling influence of an indented cylinder revolving at a high speed (diam. 18″, speed approaching 3000 r.p.m.), thereby obtaining a whirl of the material in an annular space (6″ radial depth) round the cylinder (the dimensions are somewhat

arbitrary). Certain particles separated out which appeared to be the denser ones, and by the introduction of moisture a remarkably homogeneous deposit was obtained on the wall of the casing. If the vapours of those elements that are monatomic could be subjected to a prolonged treatment in the above manner a partial if not complete separation of the isotopes might be possible, but instead of using moisture to collect the particles they could be condensed on the casing by cooling it.

Lead from different radio-active sources has different atomic masses in accordance with the principle of isotopy revealed amongst many radio-atoms in process of change. This need not be adduced as an argument that the elements below lead in atomic mass cannot have isotopic atoms. The process of evolution followed by one of devolution seems to indicate that in the genesis of the elements, according to the well-known pendulum illustration of Crookes, the swing of the pendulum laid down the stable elements up to and possibly including some lead; but the pendulum evidently swung so far as to finally lay down two elements, thorium and uranium, that are too unstable to exist indefinitely; therefore in their disintegration through a long series of changes to lead they represent the final recession of the pendulum, and the end-products of devolution have different masses amongst themselves, and these differ from that of lead produced in the first instance by evolution. Lead, therefore, has atomic masses differing slightly according to the source from which obtained or its isotopic composition; but in the process of evolution from hydrogen to lead there is no reason why two kinds of atoms chemically alike yet differing in mass may not have been produced, though apparently there has been no vast time of separation or other condition whereby such isotopes could have appeared separately in different minerals.

In conclusion, the alteration in the conductivity of the elements by the presence of isotopes of differing mass in different proportions would lead to the possibility of converting metals into insulators as one extreme and improving their conductivity as the other. This hardly seems possible from a common sense point of view, though the suggested relation leads to such a conclusion. One is therefore forced to seriously consider whether an equalisation of mass has actually taken place, and whether the variation in conductivity is due to an energy condition which cannot be altered back so as to restore the original masses to the atoms, and that coincidences in numerical relations as indicated can never have more than a hypothetical interest at best. At the same time, fractional atomic weights are so simply accounted for by the supposition of *whole-number isotopes* that one is tempted to indulge in speculations with a view of finding some new road for experimental investigation.

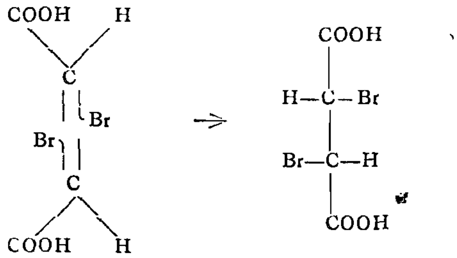
THE NATURE OF THE ETHYLENIC AND ACETYLENIC LINKINGS IN CARBON COMPOUNDS.

By W. E. GARNER.

Frankland, in his Presidential Address to the Chemical Society (*Trans.*, 1912, ci., 673), has drawn attention to the peculiar nature of the unsaturated linkings in carbon compounds. The appearance or disappearance of the unsaturated linking is accompanied by either trans elimination or trans-addition of the groups leaving or entering the molecule. Michael (*Journ. Prakt. Chem.*, 1895, [ii.], lii., 352) states thas he knows of no exception to the rule of trans-addition at the double bond of halogen acids. Even where the *cis*-reactions occur they take place much more slowly than the corresponding trans-reactions.

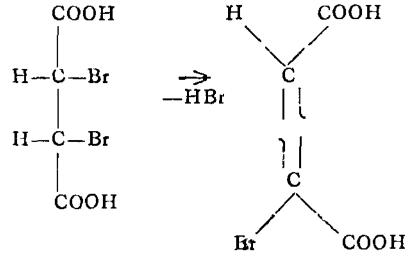
The following instances of trans-addition and elimination may be given:—

Trans-addition.



Maleic acid. Racemic dibrom-succinic acid.

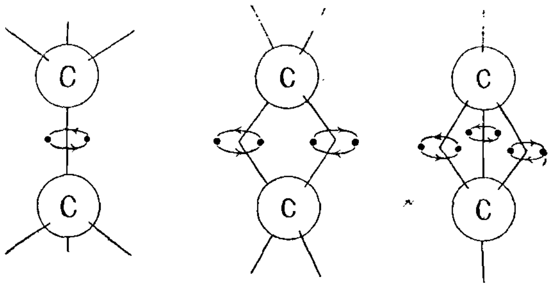
Trans-elimination.



Frankland concludes that "the uniformity with which trans-addition and trans-elimination appear to be the most favoured processes suggests that some common cause is at the root of both."

An explanation of the mechanism of trans- and *cis*-reactions can be given in terms of Bohr's theory of the arrangement of the atoms and electrons in the molecule. On Bohr's conception the hydrogen molecule consists of two positively charged hydrogen nuclei with two electrons rotating around the line joining the centres of the nuclei (Lewis, 1919, vol. iii., p. 194). Thus for the carbon linking we can assume the presence of electrons rotating around the lines joining the centres of the carbon nuclei. Diagrams I., II., and III. show a possible arrangement of the electrons for a simple, double, and triple carbon linkings respectively, and afford an explanation of the difficulty of rotation of the two carbon atoms in the case of double and triple linkings.

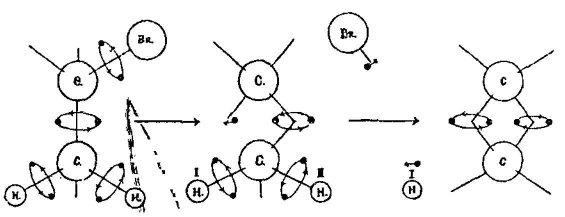
I. II. III.



The elimination of hydrobromic acid from a bromo acid is illustrated by means of the Diagrams (*a*), (*b*), and (*c*). On the extrusion of the bromine atom from (*a*) we may assume that it is accompanied by one valency electron and that the other electron remains attached to the upper carbon atom unpaired. This electron can pair with one of the valency electrons of the carbon-carbon linking, giving rise to the arrangement shown in (*b*). Diagram (*b*) shows two hydrogen atoms attached to the lower carbon atom, and either of these could be eliminated at the same time as the bromine atom. Also it is seen that an unpaired

electron is attached to one of the valencies of the upper carbon atom. The probability of this electron pairing with an electron from H(I) is greater than with an electron from H(II). The extrusion of H(I) is accompanied by the formation of a double linking, and trans-elimination of HBr takes place. *cis*-Elimination could, however, take place, but for this to occur the lower carbon atom must rotate so as to bring H(II) into the right position. Thus H(II) would not be extruded so often as H(I). The final state is given by (*c*). The intermediate stage (*b*) is only given for the sake of clearness and is not necessarily an actual step in the elimination of HBr from a bromo acid, for the hydrogen and bromine atoms may be liberated simultaneously. In any case it is evident that the rate of trans-elimination H(I)Br is greater than that of *cis*-elimination H(II)Br.

(*a*) (*b*) (*c*)



The addition of hydrobromic acid, bromine, hydrogen, &c., at the ethylenic or acetylenic linking may be treated in the same manner, and it will be seen that the reaction will be more likely to take place in the trans-position than in the *cis*-position, on account of the greater rapidity of the former process.

Bohr's theory thus supports the van 't Hoff conception of directed valency, while it explains the apparent mobility of the carbon valencies. The racemisation of optically active compounds and that particular case of racemisation, viz., the Walden inversion, is thus due to rearrangements of the valency electrons and not necessarily to any change in the directions of the carbon valencies.

The number of valency electrons at each linking may be more than two, and their arrangement in the case of the double and triple linkings may be different from those shown in the diagrams, but it seems certain that with any possible arrangement the probability of the formation of trans-compounds will be greater than that of the formation of *cis*-compounds.

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CHEMICAL ACTION PRODUCED BY RADIUM EMANATION. I.*

The Combination of Hydrogen and Oxygen.

By S C. LIND.

1. *Introduction.*

In 1903 Ramsay and Soddy reported quantitative data on the decomposition of water in a solution of radium salt (*Proc. Roy. Soc.*, 1903, lxxii., 204). In 1907 Bragg used their data to make the first comparison between the chemical and ionising effects of α-particles (*Phil. Mag.*, 1907, [6], xiii., 356). Although Bragg calculated that the number of molecules of water decomposed was almost exactly equal to the number of ions that would have been produced in air by the emanation employed, he was apparently not impressed by the equality he found, and referred to it as a "curious parallelism in numbers." In 1910 Bergwitz gave the results of the decomposition of water by α-rays from polonium deposited on copper-foil, but failed to make any comparison of the chemical and electrical relationships (*Phys. Zeit.*, 1910, xi., 273). In a brief notice in the fifth edition of his "Lehrbuch der Elektrochemie" (p. 317) Le Blanc called attention to this omission, and stated that the α-ray effect closely approached the requirements of Faraday's law. Later, Le Blanc (*Zeit. Phys. Chem.*, 1913, lxxxv., 511) published in full his calculations from Bergwitz's data on which his statement was based.

In 1911 the writer determined chemically the amount of ozone formed in oxygen by α-rays, and calculated that one molecule of ozone was formed per two pairs of gaseous ions (*Sitzb. Akad. Wiss., Wien.*, 1911, cxx., 1709; *Monatshefte*, 1911, xxxii., 295; *Am. Chem. Journ.*, 1911, xlvii., 397; *Le Radium*, 1911, ix., 104). This was the first comparison between ionisation and chemical action in a gaseous system, and hence the first instance where ionisation and chemical reaction referred to the same medium in each case.

A little later Krueger and Moeller (*Phys. Zeit.*, 1912, xiii., 729) devised an ultra-violet absorption method for the determination of ozone in very minute quantities, which Krueger employed to determine the amount of ozone formed by the passage of electrons of high velocity through gaseous oxygen ("Nernst Festschrift," p. 240; *Phys. Zeit.*, 1912, xiii., 1040). Krueger arrived at a conclusion similar to that of the writer, that one pair of ions is involved in the formation of each molecule of ozone.

In 1912 the writer (*Journ. Phys. Chem.*, 1912, xvi., 564) collected all the available data on the chemical action of α-particles, and drew from his calculations based on them the general conclusion that ionisation by α-particles and the resulting chemical action are always of the same statistical order (ion for molecule), and may be treated as illustrative of a modified form of Faraday's law. The results and applications of this theory were discussed in a number of papers (*Am. Electrochem. Soc.*, 1913, xxiv., 339; *Le Radium*, 1914, xi., 108; *Zeit. Phys. Chem.*, 1913, lxxxiv., 759). The experimental data employed by the writer in the comparison of ionisation and chemical action were largely those of Cameron and Ramsay obtained by mixing radium emanation with various gases and following the course of the reaction manometrically (*Journ. Chem. Soc.*, 1908, xciii., 966). In order to calculate the ionisation from their results a method of calculating the average path of all the α-particles in a given volume was devised (S. C. Lind, *loc., cit.*) and applied to the data of Cameron and Ramsay, with the result stated in the preceding paragraph.

More recently several chemical reactions under the influence of α-particles have been very carefully studied in the laboratory of Mdme. Curie. The decomposition of water, measured by Duane and Scheuer employing emanation in an α-ray capillary tube, showed a close equivalence between ionisation and chemical effect (*Le Radium*, 1913, x., 33). The combination of hydrogen and oxygen was studied by Scheuer in a mixture of emanation and electrolytic gases in glass spheres, by determining the diminution in pressure in a single measurement after decay of most of the emanation (*Comptes Rendus*, 1914, clix., 423). Scheuer calculated the ionisation from the Duane and Laborde empirical formula (*Comptes Rendus*, 1910, cl., 1421), and found, with a good agreement among all his experiments, that about 5·5 molecules of gas recombined for each pair of ions. A small proportion of the molecules recombined to form H_2O_2, according to Scheuer's analysis; but, approximately, we may express his result as 3·6 molecules of water formed for one pair of ions. This is a much higher value than 1·0, the average earlier calculated by the writer from the data of Cameron and Ramsay.

The decomposition of hydrogen sulphide was also measured in the Curie laboratory by Wourtzel (*Comptes Rendus*, 1913, clvii., 929) who found 3·3 molecules decom

* Published with permission of the Director of the U.S. Bureau of Mines. From the *Journal of the American Chemical Society*, xli., No. 4.

posed per pair of ions (in air), and calculated the decomposition to be 4·7 times greater than Duane and Scheuer found for water. Wourtzel later reported briefly the results of other reactions, namely, decomposition of ammonia, of nitrous oxide, and of carbon dioxide (*Journ. Russ. Phys. Chem. Soc. Proc.*, 1915, xlvii., 210, 493, 494). In all these reactions Wourtzel finds the amount of reaction to be in excess of the ionisation.

A. Debierne (*Ann. Phys.*, 1914, [9], ii., 97) has been led by the statistical disagreement found by Scheuer and by Wourtzel between ionisation and chemical action to reject the theory of ionisation put forward by the writer as the primary cause, and to substitute one based on the hypothesis that the passage of an α-particle through a gas may thermally decompose molecules lying outside the path of its ionising effect. This view of thermal decomposition is not favoured by Wourtzel (*loc. cit.*) because in some cases he found reactions actually having negative temperature coefficients.

The difference between the conclusions drawn by the writer in regard to the *rôle* played by ionisation and those of Debierne, Scheuer, and Wourtzel, based on the Paris measurements, demonstrate the desirability of further experimental work to determine, first, whether the discrepancy lies in the data themselves, or in their treatment; and, second, whether the higher chemical values, if correct, are too great to be brought into accord with ionisation. In order to settle the first point it appeared advisable to make an exhaustive experimental study of the simplest possible case, such as the combination of hydrogen and oxygen gases, in order to establish thoroughly the laws governing the reaction under various conditions as regards volume of the reacting vessel, pressure of the gases, concentration of emanation, temperature, and variation of the proportions of hydrogen and oxygen. The results of this study are reported in the present paper. In the main the experimental method of Cameron and Ramsay has been used and found well suited for the purpose. The writer was able to profit by the experience of Cameron and Ramsay to improve the manipulative details somewhat, to which attention will be called later. Following the course of the reaction manometrically enables one to study the kinetics of the reaction thoroughly. The reaction between hydrogen and oxygen has been chosen because the products of reaction are continually removed, and the system maintains itself in a constant condition with respect to the composition of the gases being acted upon.

The kinetic equation earlier deduced by the writer (*loc. cit.*) for the data of Cameron and Ramsay has been confirmed over a much wider range than was formerly possible. By varying the size of the spherical reaction bulbs, experimental confirmation has also been obtained of the law of the average path of α-particles as applied to their chemical effect in such vessels. Briefly expressed, all the assumptions previously made by the writer in treating the Cameron and Ramsay data have now been verified by direct experiment, and show that the treatment was in every way justified. The disagreement, however, between the data of Cameron and Ramsay and of Scheuer has been found to be real, and must be decided in favour of Scheuer through a good agreement between his and the new results. The explanation of the discrepancy lies in the quantities of emanation reported by Cameron and Ramsay, which were not measured *in loco*, but calculated from the amount of radium employed and the time of accumulation, which apparently led to a considerable error through incomplete evolution or collection of the radium emanation.

2. *Source of the Radium Emanation.*

The radium employed as a source of emanation was part of that produced in the co-operative work of the U.S. Bureau of Mines (*Bull.*, 104, 1915, by C. L. Parsons, R. B. Moore, S. C. Lind, and O. C. Schaefer) and the National Radium Institute. 297·8 mgrms. of radium element in the form of bromide, protected by a nine-fold excess of barium bromide, was dissolved in water containing 20 per cent of hydrobromic acid; the high percentage of the latter has proved somewhat disadvantageous on account of the liberation by the α-rays of so much free bromine. In later work the salt will be converted into chloride and only 5 per cent of hydrochloric acid employed in the solution.

The Duane apparatus for the purification of radium without the use of liquid air has been employed and given very satisfactory results (*Phys. Rev.*, 1915, [2], v., 311). The pumps employed for the apparatus were the Gaede mercury pump and the Gaede preliminary oil pump. The latter was used not only to start the mercury pump, but in handling the mercury in the three reservoirs of the Duane apparatus, and also the mercury in the McLeod gauge.

3. *Apparatus and Manipulation.*

A simple modified form of the Cameron and Ramsay (*loc. cit.*) apparatus has been used (Fig. 1). The glass reaction bulb *c* was made spherical to simplify the calculation of the average path of the α-particles, and was provided with a fine blue-glass pointer, *d*, to define sharply

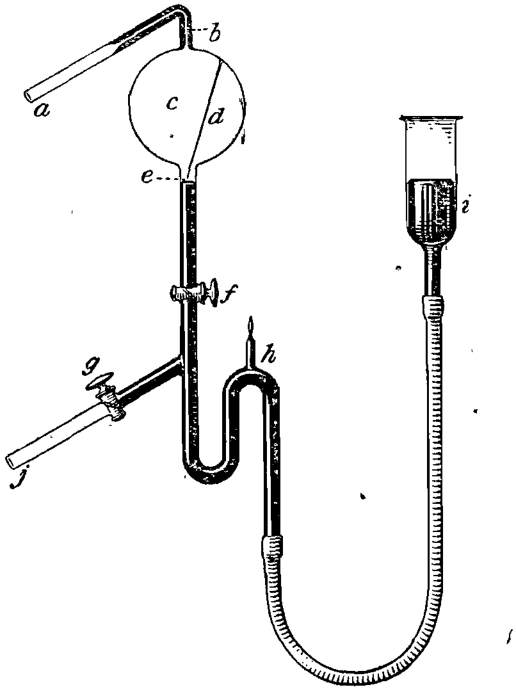

Fig. 1.

the setting of the mercury at *e*. By means of a capillary tube, *b*, connection was made at *a* with the Duane apparatus. After thorough exhaustion through *a*, *b*, and *c* to *e* by means of the Gaede mercury pump the purified emanation was introduced into *c* and sealed off at *b*.

Electrolytically prepared hydrogen and oxygen were collected over mercury in a Ramsay gas pipette (*Proc. Roy. Soc.*, 1905, A, lxxvi., 113; *Trans.*, 1907, xci., 939) sealed on at *j*, from which the gas could be passed through *g* and later through *f* to *c*, where it mixed with the emanation. This arrangement avoids bringing the emanation into contact with any stopcock grease, which caused Cameron and Ramsay much trouble in their early experiments through the continued generation around the stopcock *f* of foreign gases which would rise into *c* and vitiate the manometric results. The gas mixture can be collected below *f*, either before or after the collection of emanation

in *c*. Only the latter procedure, however, permits of the measurement of the initial pressure (usually negligible) of gas collected with the emanation. The mercury levelling bulb *i* is connected by means of rubber tubing to the glass apparatus which is provided with a gas trap at *h*.

The reaction can be begun immediately after collecting emanation, or after equilibrium with induced activity. The stopcock *f* was open only while taking readings. A water-jacket (not shown) was brought about the bulb *c* to prevent temperature fluctuations while reading.

When a drying agent was desirable a mixture of equal weights of fused sodium and potassium oxides was introduced into *c* before assembling the apparatus and fused to the wall with a weak flame. Owing to the low melting-point of the mixture it could be melted in a very thin layer at two or three spots on the inner wall without deformation of the bulb or materially affecting the spherical volume. The volume was determined by calibration with mercury after the mixture was in place.

The quantity of emanation actually employed in each experiment was determined by the γ-ray method of measurement at any time (usually the next day) after the introduction of the emanation. For this comparison three of the Bureau of Mines standards were employed containing 10·56, 59·26, and 157·3 mgrms. of radium element respectively, all of which had been compared with the U.S. Bureau of Standards international standard. (The writer wishes to take this opportunity of expressing his indebtedness to Dr. N. E. Dorsey for making these comparisons). This measurement was greatly facilitated by the fact that the whole apparatus was mounted on a single iron stand, and could be readily transported and the bulb brought into any desired position with reference to the electroscope. A correction of 0·8 per cent is applied to the γ-ray indication on account of the lag of radium C. (E. E. Rutherford, "Radio-active Substances and their Radiations," Sec. 197, also p. 659).

The course of the reaction was followed by determining the pressure at suitable intervals. The difference in mercury level between *e* and *i* was determined by mounting the whole apparatus close before a vertical mirrored millimetre glass scale. The difference thus determined was added (algebraically) to barometric pressure after all necessary corrections had been made to reduce the results to standard conditions.

(To be continued).

THE ELECTROLYSIS OF SOLUTIONS OF THE RARE EARTHS. II.*

By L. M DENNIS and P. A. van der MEULEN.

(Concluded from p. 6.)

III. *Electrolysis of a Neutral Solution of the Nitrates of the Rare Earths, Using a Diaphragm.*

The oxides of the rare earths that were obtained in the twenty fractions of the electrolysis of the chlorides were united and were boiled with an amount of nitric acid that was not quite sufficient to dissolve them completely. The excess of oxides was removed by filtration, and the neutral nitrate solution, which contained about 700 grms. of the oxides, was diluted to 10 litres. This volume of the solution was maintained throughout the electrolysis. A sheet of platinum 5 cm. square was used as anode. In other respects the cell was exactly the same as that used in the electrolysis of the chlorides. The nitric acid that accumulated in the anode cup was removed by allowing distilled water to drop into the cup from a separatory funnel, and keeping the height of liquid in the cup constant by means of a syphon. A current of 5 amperes was used. The voltage varied from 7·5 to 18. The conduct of the electrolysis, the treatment of the fractions, and the deter-

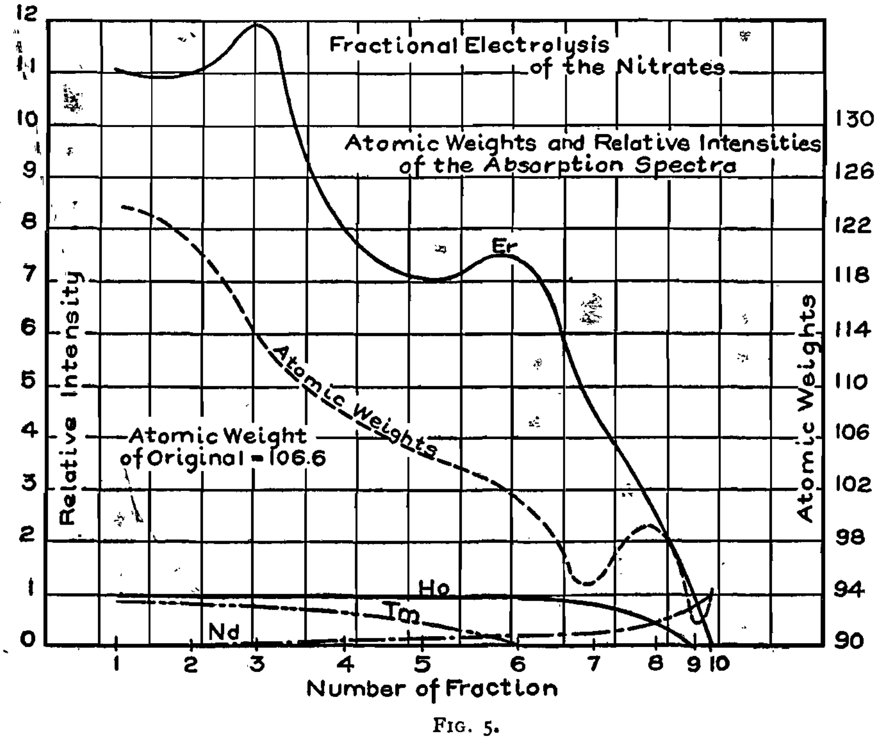

FIG. 5.

* From the *Journal of the American Chemical Society*, xxxvii. No. 9.

mination of the atomic weights of the fractions were performed in exactly the same manner as in the fractionation of the chlorides.

The fractional electrolysis of this solution of the nitrates, using a diaphragm, was found to precipitate the hydroxides of the earths about four times as rapidly as in the chloride electrolysis. It was possible that the hydrogen set free at the cathode might reduce some of the nitric acid to ammonia, as was found to be the case when no diaphragm was employed. Careful qualitative tests of the solution after the ninth fraction had been removed failed, however, to show the presence of a trace of ammonia. The results of this fractional electrolysis of the nitrates are shown in Fig. 5 and Table V.

It will be noted that in this series of electrolyses the coloured earths erbium, holmium, and thulium were present in preponderating amount in the first four fractions and were probably accompanied by considerable amounts of yttrium, as is indicated by the relatively low average atomic weight of the earths in these fractions. The last fractions, however, consist chiefly of yttrium, mixed with small amounts of cerium and neodymium that also were concentrated at this point. The method yields, therefore, in the first fractions a rapid concentration of erbium that is nearly entirely free from the didymium group; and, in the later fractions, yttrium that is quite free from the coloured earths of the erbium group, but is accompanied by any of the didymium group that may have been

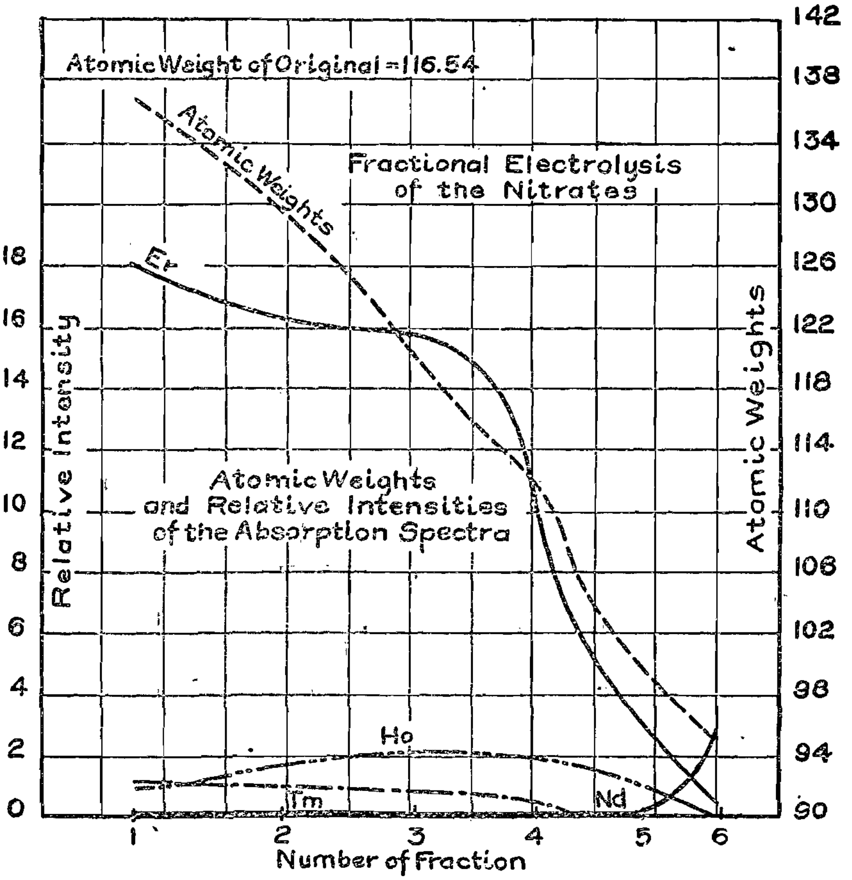

Fig. 6.

Table V.—*Original Atomic Weight*, 106·6.

Fraction No.		Atomic weights.	Weight oxides (grms.)	Volts.	Ampere hours.
1	..	123·84	67	7·45	83·68 (*a*)
2	..	120·85	75	6·90	83·9 (*a*)
3	..	114·14	80	7·33	107·9 (*a*)
4	..	108·08	85	7·25	100·7 (*a*)
5	..	104·75	77	7·37	88·43 (*a*)
6	..	101·65	92	8·00	99·9 (*a*)
7	..	94·95	72	10·00	101·7 (*b*)
8	..	98·94	60	12·75	75·68 (*c*)
9	..	91·63	40	18·00	62·27 (*d*)
10	..	94·43	16	Precipitated by oxalic acid	

Remarks.—(*a*) Colour of oxalates was pink in first fraction, becoming gradually lighter; last three fractions were pure white. (*b*) Contained no cerium. (*c*) Contained cerium. (*d*) Very slight trace of cerium.

present in the original solution. It is interesting to note that the later fractions contained detectable amounts of cerium, although qualitative tests of the original solution failed there to disclose the presence of this element. To obtain further indication as to the efficiency of the method in the separation of the earths of the erbium and yttrium groups, the first four fractions given in Table V. were combined, and were converted into a neutral solution of the nitrates. The weight of the oxides in the solution was about 220 grms., the volume of the solution was 2300 cc., and the average atomic weight of the earths was 116·54. A cell measuring 21 cc. in diameter and 20 cm. in height was used for the electrolysis. In other respects the same apparatus was employed as before. Six fractions were obtained by electrolytic precipitation. The liquid remaining after the last fraction had been removed possessed high resistance and gave no precipitate with oxalic acid. The results of this fractional electrolysis are

shown in Fig. 6 and Table VI. These results again demonstrate the efficiency of the method in speedily concentrating erbium and yttrium at opposite ends of the electrolytic fractionation, and in the concentration of the erbium earths practically free from the didymium group.

TABLE VI.—*Original Atomic Weight*, 116·54.

Fraction No.	Atomic weights.	Weight oxides (grms.).	Volts.	Ampere hours.
1	137·2	30	6·7	37
2	129·01	48	6 2	45
3	119·76	45	6 0	45
4	111·61	38	6·9	47
5	99·58	35	11·0	42
6	95·08	15	29·0	25

Remarks.—Oxalates of first three fractions were a deep pink, fading gradually.
Fraction 6 was nearly white.

of this insoluble hydroxide upon the surface of the cathode be prevented, and if the electrolyte be rapidly stirred throughout the electrolysis, a progressive precipitation of the hydroxides of the earths, in the order of their basicities, will result.

TABLE VII.—*Original Atomic Weight*, 98·94.

Fraction No.	Atomic weights.	Weight oxides (grms.).	Volts.	Ampere hours.
1 ..	97 67	8·0	6 8	9·6 (*a*)
2 ..	97·11	9·5	8·2	9·6 (*a*)
3 ..	94·36	8·5	8·0	9·6 (*a*)
4 ..	94·04	9·0	11·6	10·5 (*a*)
5 ..	93·24	6·0	19·0	8·4 (*a*)
6 ..	104·27	3·0	Precipitated by oxalic acid (*b*)	

Remarks.—(*a*) The oxalates were pink, fading rather rapidly. The oxides were light yellowish brown, and about the same colour. (*b*) Very dark brown oxide.

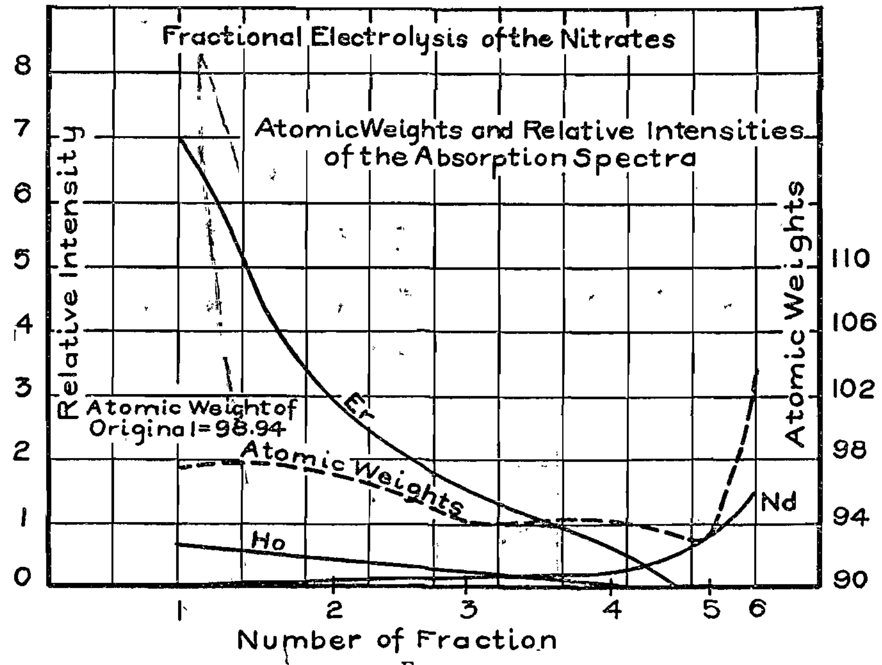

FIG. 7.

The eighth fraction, Table V., Fig. 5, showed a sudden rise in atomic weight, which was probably due to the concentration of neodymium in the later fractions of that run. With a view to ascertaining whether the method of fractional electrolysis might profitably be utilised in separating neodymium (and its group elements) from the erbium group, even when the amount of material is comparatively small, the oxides constituting the eighth fraction were converted to a neutral nitrate solution that contained about 45 grms. of rare earth oxides in 600 cc. of solution, and this was fractionally electrolysed in the same manner as before. Six fractions were obtained. The results given in Table VII. and Fig. 7 again demonstrate the ease and rapidity of the separation of neodymium from yttrium and erbium.

The separation of the rare earths by the fractional precipitation of their hydroxides upon electrolysis of solutions of their salts at voltages considerably higher than the decomposition values of the salts is probably due to the action of the hydroxyl ions, concentrated near the cathode, upon earths of different basicities. The hydroxide of the weakest base will first tend to form, and if the deposition

Summary.

1. The decomposition voltages of several neutral, normal solutions of salts of the rare earths were determined. The values were found to lie close together and to be in the neighbourhood of two volts.

2. Fractional electrolysis of a solution of the chlorides of yttrium earths yielded rapid concentration of the coloured earths in the earlier fractions, and of yttrium in the later fractions. A small amount of neodymium that was present appeared in the last fractions.

3. Fractional electrolysis, with a diaphragm, of a solution of the nitrates of these earths showed concentration of the earths similar to that obtained in the electrolysis of the chlorides. The rate of precipitation of the hydroxides of the rare earths from the nitrate solution was, however, four times as rapid as from the chloride solutions. No ammonium salts were present in the electrolyte at the close of the run.

4. Fractional electrolysis of a solution high in erbium, holmium, thulium, and yttrium gave, in a series of six fractions, no appreciable separation of the first three

earths one from another, but rapidly separated the three from yttrium.

5. In the fractional electrolysis of solutions of certain salts of the rare earths, the hydroxides of the earths are precipitated, under the conditions here described, in the order of the basicities of the earths. Rapid concentration of certain groups of earths is attained in short series of fractions.

The method is being further studied in this laboratory.

FEDERATION OF BRITISH INDUSTRIES.

A Luncheon was given at Princes Restaurant on Wednesday, the 2nd inst., by Sir Algernon Firth, a member of the Federation of British Industries, to His Excellency Liang Chi-chao and the members of his Mission.

Amongst those present were Mr. R. T. Nugent, Mr. Fitzjohn Oldham, Mr. C. Tennyson, Mr. Guy Locock, Mr. P. Lockhart, Sir W. B. Peat, Sir Robert Hadfield, Mr. S. Springer, and Mr. Henry Hobden, of the Federation of British Industries, and Prof. Carsun C. Chang (Professor of International Law at the Peking University), Mr. V. K. Ting (Head of the Department of Geological Survey in China), Mr. Singloh Hsu (Secretary to the Ministry of Finance), Mr. Weishin Yang (Member of the Board of Education), Dr. H. K. Fung, M.S. of Agr., Ph.D. (Expert, Ministry of Agriculture and Commerce and Technical Delegate of the Chinese Government to the Peace Conference), and Mr. S. G. Cheng (Publicist).

Sir Algernon Firth, in proposing the health of Mr. Liang Chi-chao, stated that Mr. Liang, who has occupied the high posts of Minister of Finance and Minister of Justice in former Administrations in China, is the acknowledged leader and exponent of those elements which tend towards the systematic and peaceful development of his country.

On the occasion of his visit to Europe he is the trusted emissary of the President of the Chinese Republic, and I understand that an important feature of his mission is to gauge the feeling which animates Western people in regard to his country. May I express at once my confident belief that Mr. Liang will carry back the conviction that genuine friendship and the desire to help are the characteristics of the British people so far as China is concerned?

I understand also that it is Mr. Liang Chi-chao's desire to expound, so far as is possible in the brief time at his disposal, the economic position in which China finds herself to-day, and perhaps to suggest in general terms the manner in which the nations of the West, and particularly Great Britain, may with advantage to themselves assist in building up a prosperous and stable condition of affairs in China.

When we in the West speak of China few of us realise that here is a country containing four hundred millions of industrious people, occupying an area comparable in size with the whole of Europe. This vast territory with its teeming population offers almost illimitable possibilities for economic development. The Chinese claim the Empire existed 8—10,000 years. Prof. Pritchard, of Oxford, allowed that they existed 2500 years B.C. as an Empire; 130 B.C. they are recorded as having ravaged coasts of Caspian Sea. Great Wall erected 300 B.C. In more modern times, 1793, Earl of McCartney went to China and reported it had 4202 walled cities, 330 million people, army 1 million, cavalry 800,000; and the time cannot be far distant when of all the countries in the world China will offer the greatest field for the beneficent enterprise of the industrial countries of the West. I say deliberately *beneficent* enterprise, because it must be obvious that the real solution of all the trials and tribulations which afflict China lies in her economic emanicipation.

But in order that this economic development shall proceed smoothly and bring about the desired results, it is essential that the policy of the open door and equal opportunity for the trade and commerce of all nations in China shall be carried into effect. I am glad to be able to assure His Excellency that the Federation of British Industries has definitely and emphatically associated itself with this policy and that its efforts will continue to be directed towards that end.

Granted that we are to see this policy of equal opportunity upheld, there remains, in my opinion, one great consideration which will prove a determining factor in bringing about a peaceful and prosperous era in China, and that is the factor of co-operation. The old order in which China held herself aloof while foreign enterprise sought to force a footing beyond her coast-lines has passed away, and the tendency to-day is towards a great and greater measure of co-operation. I can conceive of no more useful form of co-operation than that represented by the combined efforts of the Chinese, with their great good sense, their unrivalled commercial sagacity, and their probity, and of the British, upon whose merits I need not dwell. England never had an idea of exclusive trading but a high reputation for honest goods and fair and straight dealings. Indeed I am glad to notice that Anglo-Chinese co-operation is beginning to find shape in many directions, one of the latest evidences being, I believe, a proposal to form in Shanghai an Anglo-Chinese Club at which the business men of both nations will meet in friendly intercourse. All this is to the good. But we must look forward to an even greater measure of co-operation than that of which we have such promising indications to-day.

I understand that the Overseas Trade organisation of the Federation are giving careful attention to this very matter, and I hope that one of the results of their study will be the establishment of close and amicable relations between the Federation and important sources of intelligence in China.

In replying to the toast, His Excellency Liang Chi-chao enlarged upon the great possibilities that await British industrial enterprise in China in actual co-operation with the Chinese themselves. The enormous resources of China in raw material offered an illimitable field for development, but Mr. Liang considered that with the vast changes in trade and transport conditions throughout the World that has been brought about by the War, the obvious solutions lay in working up these raw materials as far as possible in China itself. The desirability of such an economic policy has been quickly recognised by the Japanese, who at a time when Great Britain had her hands tied in Europe neglected no opportuity to establish industrial enterprise through the Republic. Mr. Liang mentioned that the Chinese have awakened to a realisation that foreign assistance was necessary to her social and economic well-being. They would be inclined particularly to welcome British co-operation during the period of their country's regeneration, for the name of Great Britain stood for efficiency and integrity, and in no circumstances implied a sinister political programme. This could not be said of all countries. His Excellency therefore hoped that British enterprise would bestir itself and take a hand in the industrial development of China. It was, however, of the greatest importance to act without delay as others were in the field in search of monopolies.

Mr. P. Lockhart proposed a vote of thanks to Sir Algernon Firth for acting as host, and the proceedings then terminated.

Chemical Employers and Road Transport.—The Chemical Employers Federation has just entered into an affiliation agreement with the Motor Transport Employers Federation in respect of those of its members who employ commercial motor vehicles. The Motor Transport Employers Federation is one of the three Employers' organisations represented on the Joint Industrial Council for the Road Transport Industry, of which Council Captain F. G. Bristow, 83, Pall Mall, London, S.W. 1, is the Secretary for the Employers.

AMALGAMATED SOCIETY OF DRUG AND CHEMICAL WORKERS.

(COVENTRY BRANCH).

THIS Society held a special meeting on Wednesday, July 2, at the White Lion Hotel, Coventry, when the special feature was an address by an Organiser of the Society. Mr. A. Barrett (London) was expected to be the speaker, but he was unable to make the visit, and Mr. A. J. Gillian deputised for him.

Mr. G. H. LUSTY presided over a good attendance, which included a number of ladies.

Mr. GILLIAN put forward a strong claim for the support of the Society by all drug and chemical workers, as the Society was the only one in the country that was organised for their special benefit. The interests of the Society were also the interests of the members, as their leaders were among the best men in the trade, who could deal with all matters brought to their notice with sympathy and understanding. The Society, in conjunction with four other organisations, was represented at a conference with the Drug and Fine Chemical Masters' Association last March, when a schedule of rates of wages for the trade was agreed upon and recognised by the Masters' Association. This schedule was now operative in 43 of their business houses, and negotiations were in hand with a good many others. The schedule for men ranged from 50s. to 55s. per week, for women from 32s. 6d. to 40s. per week, for male juvenile workers from 16s. 6d. to 47s. per week, and for female juveniles from 15s. 6d. to 30s. per week. The adults were graded by their class of employment, and the juveniles by ages; and a working week of forty-eight hours with overtime rates was also stipulated. All firms who were members of the Masters' Association were bound to recognise these rates, and the speaker urged the necessity of his audience to organise in order to protect these rates if they were getting them; and if they were not, then organise to get them. He appealed for a reasonable and square deal on both sides, and he reminded them that the workers could not get round the employers by ignoring their interests or forgetting their existence. On the other hand, cordial relationship should go beyond compliments, otherwise its existence was more visionary than real. His own experience was that firms were always willing to meet the representatives from the Society, and matters that would otherwise be overlooked were righted, especially where the staff of the firm were strongly organised. Mr. Gillian asked that foremen should consider the advisability of joining the Society. They would find it valuable in keeping in touch with their staffs in many matters that would help to promote joint interest, mutual understanding, and free consultation with the heads of the firms and their employees.

At the close of the meeting there was a brisk application for membership forms.

OBITUARY

LORD RAYLEIGH.

THE death of Lord Rayleigh, O.M., D.Sc., LL.D., F.R.S., which took place on June 30, has removed one more of the prominent men of science from our midst. Lord Rayleigh was seventy-seven years of age, and for the past forty years has been in the forefront of the workers in experimental physics. His name will always be associated with the discoveries of the inert gases of the atmosphere; it was through his announcement of the discrepancies between the density of nitrogen removed from the atmosphere and that obtained from chemical compounds that drew the attention of Prof. Ramsay to the subject and resulted in their combined and successful investigations.

Lord Rayleigh received the Order of Merit at its institution in 1902; he was an Officer of the French Legion of Honour; and in 1905 he was appointed a member of the Privy Council.

He leaves two sons; the elder, Robert John, is Professor of Physics in the Imperial College of Science and Technology and is distinguished for his researches on radio-activity, and the younger is a naval officer.

PROFESSOR ADRIAN BROWN.

THE death took place on Wednesday, July 2, at his residence at Northfield, near Birmingham, of Prof. Adrian J. Brown, M.Sc., F.R.S., who since 1899 had been Professor of Biology and Chemistry of Fermentation at the University of Birmingham, and Director of the School of Brewing. Born in 1852, and the son of the late Mr. Edwin Brown, F.G.S., of Burton-on-Trent, he was for some time an assistant at St. Bartholomew's Hospital, and was later a chemist to Messrs. T. Salt and Co., Burton-on-Trent, and was the author of several works on chemistry. At one time he was examiner in Biological Chemistry at the Institute of Chemistry. It was only on the previous Sunday that Prof. Brown's wife died. Husband and wife were interred together at Northfield Cemetery on July 4.

NOTES.

THE Educational Committee of the Russo-British (1917) Bratstvo (Fraternity) propose to inaugurate a course of Commercial Emergency Lectures, to be delivered by British and Russian experts during the months of July, August, and September, on the various branches of Russian Export and Import Trade and the technicalities of Russian business operations. These lectures will be delivered in English, and are designed to afford those intending to start as commercial travellers and agents the means of acquiring an indispensable elementary knowledge of the conditions and particulars of business operations in Russia. The requirements of the Russian market in every branch will probably prove before long to be enormous, and will open great possibilities for all industrial countries throughout the world. It would be of great service if information could be obtained from various authoritative quarters as to the most suitable and convenient manner in which such lectures could be arranged so as to meet the wishes of applicants and the needs of the moment. It is proposed to arrange for the following courses:—Russian Economics; Commercial Geography; Legal and Social Conditions; Agrarian Problems—Needs of Agriculture; Textile Industry; Mining, Metallurgy; Chemical Industry; Co-operation; Russian History; Russian Commercial Language; Ethnography. Informal instruction in industry and trade, as mentioned in the scheme above, and such other subjects as may appear of practical importance, will be delivered if found necessary. Further particulars may be obtained from the Secretary, Baron A. F. Meyendorff, 26, Chester Square, S.W. 1.

THE official opening of the British Scientific Products Exhibition took place on Thursday, July 3, at the Central Hall, Westminster. Lord Sydenham, G.C.S.I., F.R.S., President of the Guild, took the chair, and after a few introductory remarks an opening address was delivered by the Most Hon. the Marquess of Crewe. His Lordship, after explaining the objects of the Exhibition, dwelt upon the part that British scientific application had played in the war, the unpreparedness with which we entered into the conflict, the rapidity with which the knowledge and invention of the scientific technologist was applied to the need of the moment, and to the success that followed. His

Lordship referred to the growing interest in science and to the recognised need for scientific training and application in all branches of activity. The Exhibition would be the means of bringing home to all the great advances that had been made under the stimulus of the war, and would give some idea of the possibilities that were opened now that this great fund of energy was turned into peaceful channels. In conclusion reference was made to the loss which the world of science had sustained by the death of Lord Rayleigh. Lord Fletcher Moulton, Sir Philip Magnus, Sir Richard Gregory, Sir J. S. Young, and others spoke, and the Exhibition was declared open. Unfortunately the arrangements of the exhibits was far from complete, and in the confusion of workmen, packing cases, and cleaners it was difficult to form any idea of the particular exhibits — a description must be left for a later issue; but it was quite evident that an immense amount of interesting material has been accumulated.

POPULAR CHEMICAL DICTIONARY.—We understand tha Mr. C. T. Kingzett, F.I.C., the Chairman of the "Sanitas" Co., Ltd., and who was one of the original founders of the Institute of Chemistry, is preparing for early publication by Messrs. Ballière, Tindall, and Cox, London, an abridged "Popular Chemical Dictionary" in a single volume. Apart from the educative value of such a production, including its use in schools and public libraries, it should be of great service as a work of reference not only to practical chemists but also to brokers, dealers, and business men generally who are natually interested in the thousand and one articles finding concise description in such a book.

MINISTRY OF HEALTH ACT, 1919.—Under the provisions of Section 11 (1) of the above Act, an Order in Council has been made fixing July 1 as the day upon which the Act is to come into operation. On that day all the powers and duties of the Local Government Board will pass to the Ministry of Health, the question of the transfer to other Government Departments of any existing powers or duties not relating to matters affecting or incidental to the health of the people being reserved for consideration and decision at an early date. All communications on subjects previously within the jurisdiction of the Local Government Board should accordingly, on and after July 1, be addressed to the Secretary, Ministry of Health, Whitehall, S.W. 1.

WELSH COAL FOR STEAM WAGONS.—The National Council of the Commercial Motor Users Association (Inc.) has for some time been making representations to the Coal Controller in favour of the withdrawal of the present restrictions upon supplies of Welsh Steam Coal in many parts of the country. The Council has now received notification from the Coal Controller that permits may be obtained by owners of steam wagons and tractors for the amount of Welsh steam coal required on making application in writing to Finlay Gibson, Esq., Secretary of the South Wales Coal and Coke Supply Committee, Cardiff.

NOTES FROM FOREIGN SOURCES

Action of Carbon Disulphide on Nitro-methane.—Erich Freund.—In presence of alcoholic potash carbon disulphide reacts with nitro-methane to give a substance of formula $C_2HO_2NS_2K_2$. The brown colour which appears especially in aqueous solution suggests the formation of a dithio or carbithio acid. If the substance is boiled with strong aqueous potash the colour disappears and on cooling colourless needles crystallise out. These are identical with Steinkopf's potassium nitroacetate; the liquid contains potassium sulphide. It has been shown that dithiobenzoic acid when boiled with alcoholic potash yields benzoic acid and potassium sulphide, and apparently this is a characteristic reaction of all carbithio acids, which suggests that the new substance is the potassium salt of the hitherto unknown nitro-dithio-acetic acid, its formula being

HC : N(=O)—OK
|
CS.SK

This formula is confirmed by the fact that the aqueous solution of the substance is neutral and remains neutral on the addition of hydorchloric acid, until the amount of acid added exceeds the proportion of one molecule of acid to one of salt. The addition of more acid causes the appearance of an acid reaction. Apparently the aci-compound

HC : N(=O)—OH
|
CS.SK

is first formed, and is then converted into the still neutral true nitro acid

$CH_2.N \lessgtr {}^{O}_{O}$
|
CS.SK.

When all the isonitro salt is converted into this last substance the reaction becomes acid.

ASSISTANT Chemist required immediately by large firm of Indiarubber manufacturers. State age, qualifications, and salary required.—Address, A. T., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

ASSISTANT Metallurgical Chemist (21) requires Situation. Experience in both Ferrous and Non-ferrous Analyses, Case-hardening, Heat Treatment, Mechanical Testing, and Metallography.—Address, A. M. C., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

ASSISTANT Chemist wanted, 25 to 35 years of age. Applicant must have had thoroughly good training. Work principally Analytical with Precious and Non-ferrous Metals. State full particulars as to age, qualifications, experience, and salary required to Managing Director, The Sheffield Smelting Co., Ltd., Sheffield.

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BUNGE BALANCE, as new, with Oertling weights, £16; Copper WATER OVEN, 12×11×10 inches, with stand, £4; MERCURY PUMP, £2. Other Apparatus. On view, Manchester.—Address, in first instance, B., Hill View, Hathersage, Derbyshire.

TWO Long-beam OERTLING BALANCES, in thorough working condition, with box of gramme Weights, £8 each.—Address, I. H., Analytical Laboratory, 73, Mark Lane, London, E.C. 3.

WANTED, one Pfleiderer type MIXING MACHINE, preferably non jacketted and without tilting gear, in brass, gun-metal, cast-iron, or other material. If possible, the machine and top cover to withstand a test pressure of 50 lbs. per square inch. The effective capacity to be 150 to 200 gallons.—Address, M. M., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

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A SYSTEMATIC PROCEDURE FOR THE DETECTION OF THE ACIDS OF GROUP I.*

By LOUIS J. CURTMAN and DAVID HART.

Introduction.

There are a number of schemes in the literature for the detection of the acids of Group I., but very few are given with experimental data or with specific and adequate directions for their proper execution in the laboratory. The distillation method with phosphoric acid devised by A. A. Noyes (*Journ. Am. Chem. Soc.*, xxxiv., 609) is supported by experimental data and doubtless gives good results in the hands of experienced chemists; but it seems to us altogether too complicated for students in qualitative analysis. We have therefore attempted in this paper to provide a systematic procedure for the detection of the acids of Group I. which shall be rapid, efficient, and capable of giving good results when used by the inexperienced student. Provision has also been made in this scheme for the rough estimation of each of the acid radicals detected.

Outline of the Procedure.

Except where special tests are to be made, as in the case of carbonates, the scheme of analysis proposed in this paper is intended for the detection of the acids when they are in solution in the form of their sodium salts. Such a solution known as the "prepared solution" is generally obtained by boiling the original substance with a strong Na_2CO_3 solution and filtering the mixture. The filtrate is made slightly acid with acetic acid and then slightly alkaline with NaOH.

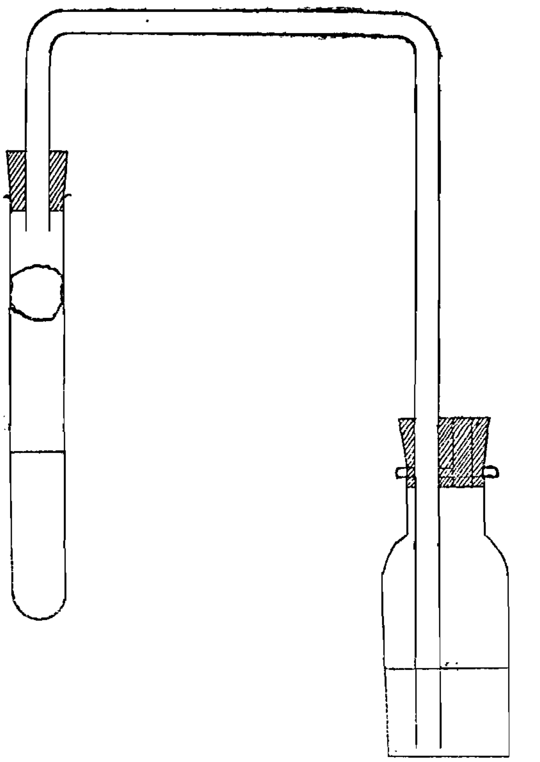
Advantage is now taken of the fact that the acids of Group I. may be precipitated in a slightly alkaline solution with a mixture of $BaCl_2$ and $CaCl_2$. Since $BaSO_4$ is insoluble in acids it may be separated from the barium salts of other acids by the addition of HCl (1 : 2), which was found to dissolve the Ba and Ca salts of all the other acids. The filtrate will now contain the following acids:—Sulphite, oxalate, fluoride, borate, tartrate, arsenite, arsenate, and phosphate as Ba and Ca salts dissolved in HCl. By the use of an oxidising agent such as H_2O_2, the sulphite is oxidised to sulphate, which then separates as $BaSO_4$ in consequence of the excess of $BaCl_2$, which is added. At the same time arsenites are oxidised to arsenates.

Experiment having shown that 500 mgrms. of most of the acids of Group I. in the form of Ba salts are not held completely in solution by an excess of acetic acid, $(NH_4)_2SO_4$ is next added to remove the Ba. To the filtrate sufficient NH_4Cl is now added to prevent borates and tartrates from precipitating upon making the solution alkaline with NH_4OH. The filtrates containing the borate and tartrate is divided into two portions. The former is tested for by means of an alcoholic solution of turmeric after concentration and treatment with concentrated HCl and methyl alcohol. The tartrate is tested for by the formation of the blue copper complex which it forms with copper in NaOH solution, due provision being made for the disturbing influence of ammonium salts and arsenites, both of which give a similar test. The precipitate consisting of oxalate, fluoride, arsenate, phosphate, and sulphate,* in the form of their Ca salts, is acidified with an excess of acetic acid.

Phosphate and arsenate go into solution, leaving a residue of CaF_2, CaC_2O_4, and $CaSO_4$ (see *ante*). The precipitate is divided into two equal portions. The first is treated with H_2SO_4, and tested for oxalate by the addition of $KMnO_4$. The other portion of the precipitate is dried in a platinum or lead crucible and the etch test then applied. (For roughly estimating the relative amounts of F and C_2O_4 in this precipitate see Note 18 following scheme). The filtrate consisting of arsenate and phosphate is treated with H_2SO_3 to reduce the arsenate to arsenite. The latter is then completely precipitated with H_2S. The filtrate, after the removal of the H_2S, is tested for phosphate by means of $(NH_4)_2MoO_4$. Special provision is made for the detection of carbonates (see Note 1*a*), chromates (see Note 1*b*), as well as for distinguishing between arsenites and arsenates (see Note 9).

Notes.

1*a*. *Carbonates* are separately tested for and roughly estimated by means of the apparatus shown in the *diagram. This consists of a test-tube and a small w.m.*



bottle connected by a glass tube bent twice at right angles. The short limb passes through a one hole rubber stopper which tightly fits the test-tube. The small wide mouth bottle is fitted with a rubber stopper with two perforations through one of which passes the long limb of the tube and extends to within ¼ inch from the bottom of the bottle. To make test, introduce 0·5 grm. of the substance into the test-tube. Put 15 cc. of saturated $Ba(OH)_2$ solution into the bottle. Keep away from flame and stopper immediately. Obtain a little absorbent cotton to form a

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* Some $CaSO_4$ always forms at this point for the reason pointed out in Note 17 following scheme.

loose plug near the mouth of the tube. Now add 10 cc. 3 per cent H_2O_2 and 5 cc. dilute HCl, quickly introduce the cotton, and tightly stopper. Heat gently until no more bubbles pass through the $Ba(OH)_2$; then remove stopper from the test-tube. A cloudiness or white precipitate shows the presence of a carbonate. By this procedure 1 mgrm. of carbonate can be detected in the presence of 500 mgrms. of sulphite. (See Test).

b. Chromates are not provided for in the scheme because they are incompatible with sulphites and thiosulphates in neutral or acid solutions. If the prepared solution is colourless it is safe to conclude that chromates are absent, because as little as 1 mgrm. of CrO_4 gives a decidedly yellow colour to the solution. In the absence of sulphites and thiosulphates, chromates fit without difficulty into the scheme, and will be found in the filtrate containing the borate and tartrate. The test for tartrate remains unchanged, since CrO_4 does not interfere. However, to test for borate it will be necessary to remove the CrO_4 by adding 10 cc. $2N.BaCl_2$ to the solution slightly acid with acetic acid. The filtrate is then tested for borate in the usual manner.

2. A "prepared solution" is one which contains the acids in the form of their sodium salts. Such a solution may be obtained by boiling 1 grm. of the finely powdered substance with 20 cc. $3N.Na_2CO_3$ with constant stirring for several minutes. If NH_3 is given off continue the boiling (adding more Na_2CO_3 solution if necessary) until no more of this gas is given off. Filter. The filtrate is the "prepared solution."

3. A mixture of $BaCl_2$ and $CaCl_2$ will precipitate 1 mgrm. each of CrO_4, SO_4, SO_3, C_2O_4, F, and PO_4. The least amount of the other radicals precipitated by the same reagents in a volume of 25 cc. are:—8 mgrms. AsO_3, 3 mgrms. AsO_4, 85 mgrms. BO_3, 70 mgrms. $C_4H_4O_6$, and 40 mgrms. S_2O_3.

4. In the filtration of the precipitates formed by barium and calcium salts it is best to use a double filter.

5. If the precipitate is too small to transfer to a beaker puncture the filter with a clean platinum wire and pass HCl (1 : 2) through the filter several times in small portions.

6. HCl (1 : 2) is the strength necessary to hold all the acids except SO_4 in solution.

7. If thiosulphates are present as indicated by the precipitate of S and the oxidation of the latter on ignition to SO_2, a precipitate will be obtained later with H_2O_2, even though sulphites are absent, due to the liberation of H_2SO_3 from the thiosulphate by the HCl. A separate test for sulphites in the presence of thiosulphates is therefore necessary. The following procedure is a modification of that given by A. A. Noyes ("Qualitative Chemical Analysis," 1913, p. 113), which is based on the difficult solubility of strontium sulphite (see Test Exp. V.):—15 cc. of the prepared solution is slightly acidified with acetic acid and then made faintly alkaline with NH_4OH. 3 cc. $N.Sr(NO_3)_2$ are added, the mixture heated to boiling, allowed to stand fifteen minutes, and filtered.

Residue in $SrSO_3$.	*Filtrate* may contain SrS_2O_3.
Residue in $SrSO_3$. Wash with cold water. Pour 3—4 cc. of dilute HCl through the filter. To the solution add 5 cc. $2N.BaCl_2$, and filter off any precipitate which forms. To the clear filtrate add Br water until the yellow colour persists. Boil until all the Br is given off. A white precipitate of $BaSO_4$ shows the presence of a sulphite.	*Filtrate* may contain SrS_2O_3. Add 1—2 cc. concentrated HCl, heat to boiling, and allow to stand thirty minutes. A white turbidity or yellow precipitate of S indicates the presence of thiosulphates.

The above procedure is capable of detecting 1 mgrm. of SO_3 in the presence of 500 mgrms. S_2O_3 and 5 mgrms. S_2O_3 in the presence of 500 mgrms. of SO_3.

8. Borates in amounts less than 85 mgrms. are not precipitated by $BaCl_2$. To detect less than this amount see Note 15.

9. Only amounts of tartrate greater than 70 mgrms. are precipitated by $CaCl_2$. To detect less than this amount see Note 16.

10. The limit of sensitiveness for arsenite in this scheme is 8 mgrms. To detect less than this amount acidify a portion of the prepared solution with HCl and pass in H_2S. An immediate yellow precipitate of As_2O_3 shows the presence of an arsenite.

11. The scheme does not distinguish between an arsenite and an arsenate due to the use of H_2O_2 which oxidises any arsenite to arsenate. To determine the state of oxidation of the arsenic in the original substance acidify 10 cc. of the prepared solution with acetic acid and make it distinctly alkaline with NH_4OH. Add 10 cc. magnesia mixture, and filter. Wash the precipitate twice with water, and dissolve it in HCl. Add 30 cc. H_2SO_3, and boil off the excess. Pass in H_2S. A yellow precipitate of As_2S_3 shows the presence of an arsenate. The filtrate from the magnesia mixture precipitate is made acid with HCl, heated to boiling, and treated with H_2S. An immediate yellow precipitate shows the presence of an arsenite.

12. As H_2SO_4 and H_3PO_4 are used in the manufacture of H_2O_2 it not infrequently happens that considerable amounts of these acids are found in certain commercial grades of H_2O_2. Hence before using, a control test for SO_4 and PO_4 should be made. Only when the control tests are negative or slightly positive can the peroxide be used. If at this point in the scheme a precipitate is obtained with H_2O_2, immediately or on boiling, a sulphite is present, and time may be saved by adding 10 cc. $2N.(NH_4)_2SO_4$ before filtering and thus save a filtration.

13. Barium is removed at this point because, contrary to the general statements made in the literature, it was found that even a huge excess of acetic acid failed to hold in solution 500 mgrms. PO_4, CrO_4, F, AsO_4, or C_2O_4 in the form of their Ba salts (see Test Exp. III.).

14. It is necessary to add 5 grms. NH_4Cl and also to dilute the solution to 100 cc. in order to keep the tartrate and borate in solution. NH_4Cl is added in preference to $(NH_4)_2SO_4$, because the latter would increase the quantity of $CaSO_4$ which comes down later with the oxalate and fluoride.

15. A test for borate at this point indicates the presence of over 85 mgrms. If less than this amount is to be detected apply the procedure given in the scheme directly to 5 cc. of the prepared solution. Always compare the test obtained with a control which is made as follows:—To 5 cc. of water add 3 cc. concentrated HCl, 10 cc. methyl alcohol, and 1 cc. of a saturated solution of turmeric powder in 95 per cent ethyl alcohol. To form an estimate of the amount of BO_3 present compare test with that obtained with a known amount of BO_3.

16. The double evaporation with excess of NaOH is made to ensure the removal of NH_4 salts, which give a similar test. A negative test at this point would show the absence of more than 70 mgrms. $C_4H_4O_6$. To detect smaller amounts of this acid apply the procedure given in the scheme under tartrates directly to a portion of the prepared solution, remembering, however, that if arsenites are present they must be first oxidised by adding 20 cc. 3 per cent H_2O_2 to the prepared solution before adding 10 cc. 25 per cent NaOH. The mixture is then evaporated and the test completed as given in the scheme.

17. Due to the presence of Ca and SO_4 a precipitate of $CaSO_4$ is *always* obtained at this point. Hence the formation of a precipitate at this stage of the analysis does not necessarily prove the presence of C_2O_4, F, AsO_4, or PO_4. No way of preventing the formation of $CaSO_4$ at this point was found, although numerous devices and procedures were tried.

18. Under the conditions given in the scheme 4 mgrms. is the smallest amount of F which will precipitate as CaF_2

SCHEME FOR THE ACIDS OF GROUP I. (1).

MAKE a "prepared" solution of 1 grm. of the substance (2). Just acidify the solution with acetic acid and make slightly alkaline with NaOH. Add 10 cc. each of $2NBaCl_2$ and $2NCaCl_2$ (3). Filter (4). Reserve the filtrate for the acids of Groups 2 and 3. Wash the precipitate once with water and transfer to a beaker (5). Treat the precipitate with 45 cc. (1 : 2) HCl (6) and 5 cc. $2NBaCl_2$. Allow to stand 5 minutes and filter.

Residue is $BaSO_4$ and S.

Dry, transfer to a crucible and ignite to burn off sulphur. A residue of $BaSO_4$ insoluble in dilute HCl proves the presence of SO_4. SO_2, which is formed by the burning of the sulphur, proves the presence of S_2O_3 (7).

Filtrate may contain SO_3, BO_3 (8), $C_4H_4O_6$ (9), C_2O_4, F, AsO_3 (10), AsO_4 (11), PO_4, Ca, Ba, and an excess HCl. Add 20 cc. 3 per cent H_2O_2 (12). Boil the mixture vigorously until all the H_2O_2 has been decomposed, and filter.

Residue is $BaSO_4$, which is insoluble in dilute HCl, showing the presence of SO_3 (7).

Filtrate may contain BO_3, $C_4H_4O_6$, C_2O_4, F, AsO_4, PO_4, Ca, Ba, and an excess HCl. Add $2N(NH_4)_2SO_4$ (13) drop by drop until precipitation is complete. Boil for one minute, filter while hot on a double filter. Reject residue of $BaSO_4$.

Filtrate may contain BO_3, $C_4H_4O_6$, C_2O_4, F, AsO_4, PO_4, Ca, SO_4, and an excess of HCl. Add 5 grms. NH_4Cl, dilute to 100 cc. (14), make distinctly alkaline with NH_4OH, and filter.

Filtrate may contain $Ca_3(BO_3)_2$ and $CaC_4H_4O_6$. Divide into two equal portions.

Test for BO_3 (15).

Concentrate first portion to 5 cc. Filter off any precipitate which forms. To clear filtrate in a test-tube add 3 cc. concentrated HCl, 10 cc. CH_3OH, and 1 cc. turmeric solution. An orange or red colouration shows the presence of BO_3.

Test for $C_4H_4O_6$ (16).

Transfer second portion to an evaporating dish. Add 10 cc. 25 per cent NaOH. Evaporate almost to dryness. Add 20 cc. water. Evaporate again almost to dryness. Add 10 cc. water and filter if necessary. *Cool* filtrate, add 2·5 cc. 25 per cent NaOH and 1·5 cc. 2N $CuSO_4$. Shake vigorously for one min. and filter immediately on a previously prepared filter. To the clear filtrate add 2 cc. concentrated NH_4OH. A blue coloration shows the presence of $C_4H_4O_6$.

Residue may contain CaC_2O_4, CaF_2, $Ca_3(AsO_4)_2$, $Ca_3(PO_4)_2$, and $CaSO_4$ (17). Transfer to a beaker, make acid with acetic, add 10 cc. 36 per cent acetic acid in excess and 5 cc. 2N $CaCl_2$. Filter.

Residue may consist of CaC_2O_4, CaF_2, and $CaSO_4$. Divide into two equal portions.

Test for F (18).

Dry the first portion, transfer to a lead or platinum crucible, and apply the etch test for fluorides.

Test for C_2O_4 (19).

Transfer second portion to a test-tube. Add 5 cc. dilute H_2SO_4 and a few drops of $KMnO_4$. Bleaching of $KMnO_4$ proves the presence of C_2O_4.

Filtrate may contain PO_4, AsO_4, Ca, and an excess of acetic acid. Make slightly alkaline with NH_4OH, then acid with HCl. Add 2·5 cc. concentrated HCl and 30 cc. H_2SO_3 (20). Allow to stand 10 minutes in cold. Boil vigorously until all SO_2 is expelled. Pass in H_2S while hot till precipitation is complete, and filter.

Residue is As_2S_3 (21).

Filtrate may contain PO_4, Ca, and an excess of HCl. Make alkaline with NaOH, then acid with HNO_3. Add 2 cc. $(NH_4)_2MoO_4$. Warm. A yellow precipitate shows the presence of PO_4 (22).

(Test Exp. III.) To detect less than this amount apply the etch test directly to the original substance.

If an estimate of the amount of F is desired the following modified procedure should be employed. The first portion is dried and ignited to convert the CaC_2O_4. It is then treated with acetic acid, leaving a residue of CaF_2 and $CaSO_4$. It was found that ignited CaF_2 was not appreciably transposed by boiling with Na_2CO_3, while $CaSO_4$ under the same conditions was completely transposed. Accordingly, the residue of CaF_2 and $CaSO_4$ is dried, ignited, cooled, powdered, transferred to a beaker, boiled for five minutes with 15 cc. $3N.Na_2CO_3$, and the residue washed by decantation. The residue is again boiled with 15 cc. Na_2CO_3 solution, the mixture filtered, and the residue washed free of SO_4. The precipitate is then treated with an excess of acetic acid. A white residue is CaF_2. Confirm by drying the precipitate, transferring to a platinum or lead crucible, and applying the etch test.

19. A rough estimate of the amount of oxalate present can be made by using a standard solution of $KMnO_4$ (1 cc. = 10 mgrms. C_2O_4), and adding the latter drop by drop from a graduated pipette until a faint pink colour persists.

20. H_2SO_3 is used to reduce the arsenate. The excess of SO_2 must be boiled off because the latter reacts with H_2S, yielding a precipitate of sulphur, a large amount of which would obscure the test.

21. A precipitate of As_2S_3 indicates the presence of either arsenite or arsenate. To determine the state of oxidation of the arsenic in the original substance see Note 9.

22. The amount of phosphate present may be estimated by adding an excess of $(NH_4)_2MoO_4$. As this reagent is expensive and the precipitate voluminous it is best to take 1/10 of the filtrate, make it alkaline with NaOH and then acid with HNO_3. Add 10 cc. of $(NH_4)_2MoO_4$, warm, and allow to stand. The size of the precipitate is a rough measure of the amount of phosphate present.

Test Experiments.

I.—*The Determination of the Minimum Amount of Each of the Acids of Group* I. *Precipitated by Barium and Calcium Ions.*

To separate solutions containing increasing amounts of the acid radical as the sodium or potassium salt, 10 cc. of $2N.BaCl_2$ or $2N.CaCl_2$ were added, making a total volume of 25 cc. The solutions were vigorously stirred, and allowed to stand for five minutes. The results obtained are recorded in Table I.

Table I.

No.	Salt used.	Acid radical.	Least amount of acid radical precipitated by barium chloride. Mgrms.	Least amount of acid radical precipitated by calcium chloride. Mgrms.
1.	Na_2CO_3	CO_3	1	3
2.	K_2SO_4	SO_4	1	35
3.	K_2CrO_4	CrO_4	1	>500
4.	Na_2SO_3	SO_3 (1)	3	30
5.	$Na_2HPO_4.12H_2O$	PO_4	2	1
6.	$K_2C_2O_4.H_2O$ ..	C_2O_4	25	1
7.	$NaAsO_2$	AsO_3 (2)	8	40
8.	$Na_2HAsO_4.7H_2O$	AsO_4	25	3
9.	$Na_2B_4O_7$	BO_3	85	95
10.	$NaKC_4H_4O_6.H_2O$	$C_4H_4O_6$	250	70
11.	NaF	F	1	1
12.	$Na_2S_2O_3.5H_2O$ ..	S_2O_3	40	>500

1. The Na_2SO_3 used was analysed quantitatively and found to contain 81 per cent Na_2SO_3 and 18 per cent Na_2SO_4; hence a modified procedure was necessary to obtain the limit of sensitiveness for $BaSO_3$. Separate solutions, each containing 1, 2, and 3 mgrms. SO_3 respectively, were treated in centrifugal tubes with 10 cc. $2N.BaCl_2$ in a total volume of 25 cc. The mixtures were then centrifuged for two minutes at 3000 R.P.M. and the supernatant liquids poured off. One cc. of dilute $H_2SO_4(3N)$ was added to each tube and the precipitate stirred up. A drop of 0·5 per cent $KMnO_4$ was added to each. The first was not bleached. In the second tube a faint pink colour persisted, while the third remained colourless even after three drops of the $KMnO_4$ were added. The limit of sensitiveness for $BaSO_3$ is therefore 3 mgrms. SO_3. By a similar procedure the limit of sensitiveness for $CaSO_3$ was found to be 30 mgrms. SO_2.

2. The $NaAsO_2$ used was found to contain carbonates; hence a different procedure was necessary. By the usual procedure 5 mgrms. of AsO_3 gave a cloudiness with $BaCl_2$. Separate solutions, each containing 5, 6, 7, and 8 mgrms. of AsO_3 respectively, as $NaAsO_2$ treated in centrifugal tubes with 10 cc. $2N.BaCl_2$ in a total volume of 25 cc. The solutions were centrifuged for two minutes at 3000 R.P.M. and the supernatant liquids poured off. One cc. each of concentrated HCl and H_2O were added to dissolve the precipitate and 10 cc. of a saturated solution of H_2S in water. A blank test was run with 1 cc. of a saturated solution containing 0·5 mgrm. AsO_3 and 1 cc. concentrated HCl. To the mixture was added 10 cc. of H_2S water. The results are given in Table II.

Table II.

No.	AsO_3 (mgrms.).	Result at end of three minutes.
1.	5	Very slight ppt.
2.	6	Slightly larger ppt.
3.	7	Larger ppt.
4.	8	Very good test.
Blank	0·5	Ppt. 3 times size of ppt in 4.

By a similar procedure the limit of sensitiveness for calcium arsenite was found to be 40 mgrms. AsO_3.

II.

In all the following experiments sulphates, carbonates, sulphites, and thiosulphates were omitted for obvious reasons.

(*a*) *To Determine the Action of Acids upon* 500 *mgrms. of each of the Acids of Group* I. *in the Form of their Barium Salts.*

Action of Acetic Acid.—Separate solutions, each containing 500 mgrms. of one of the acids of Group I. were treated with 10 cc. of 36 per cent acetic acid and 10 cc. $2N.BaCl_2$ in a total volume of 50 cc. The solutions were vigorously stirred and allowed to stand five minutes. A precipitate was obtained with CrO_4, PO_4, C_2O_4, AsO_3, AsO_4, and F. These experiments were repeated, using twenty times the theoretical amount of acetic acid necessary to hold them in solution, but in each of the above cases a precipitate was obtained.

Action of Formic Acid.—The above experiments were repeated using a huge excess of formic acid in place of acetic. The same results were obtained.

Action of HNO_3 *and* HCl.—Upon repeating these experiments with 10 cc. dilute $HNO_3(3N)$ it was found that all the above acids were kept in solution. The same results were obtained with 10 cc. dilute HCl(3N).

(*b*) *To Determine the Action of Acids upon* 500 *mgrms. of the Acids of Group* I. *in the Form of their Calcium Salts.*

Action of Acetic Acid.—Separate solutions, each containing 500 mgrms. of one of the acids of Group I., were treated with 10 cc. 36 per cent acetic acid and 10 cc. $2N.CaCl_2$ in a total volume of 50 cc. The solutions were vigorously stirred and allowed to stand five minutes. Oxalates and fluorides gave precipitates, the others were kept in solution.

Action of HNO_3 *and* HCl.—The above experiments were repeated, replacing the acetic acid by 10 cc. dilute HNO_3. Only the oxalate gave a white precipitate. The same results were obtained with 10 cc. dilute HCl. Experiments were then made with the oxalate alone, increasing the amount of HCl or varying its strength as follows:—To a solution containing 500 mgrms. C_2O_4 as $K_2C_2O_4$ 10 cc. of $2N.CaCl_2$ were added. The solution was stirred vigorously and allowed to stand five minutes. The precipitate was filtered off, washed with water, and transferred to a beaker. A solution of HCl of definite concentration was added, 1 cc. at a time, till the precipitate was completely dissolved. The results obtained are given in Table III.

Table III.

Strength of HCl.	Per cent HCl.	Cc. used.
1 : 3	10	55
1 : 2	13	40
2 : 3	16	35
1 : 1	20	30

Conclusion.—(*a*) All the acids of Group I., with the exception of sulphates when precipitated by a mixture of $BaCl_2$ and $CaCl_2$, may be readily taken into solution with 40 cc. HCl (1 : 2). In the scheme 45 cc. are used to insure a slight excess of HCl. (*b*) Acetic acid (10 cc. 36 per cent) may be used to separate oxalates and fluorides from borates, tartrates, chromates, phosphates, and arsenates, when these acids are precipitated as calcium salts. Since the Ba salts of these acids are not similarly affected by acetic acid it is necessary to remove the Ba by precipitation with a sulphate before the above separation can be made.

III.—*To Determine the Minimum amounts of* CaC_2O_4 *and* CaF_2 *which may be respectively precipitated by* $CaCl_2$ *in a Definite Volume in the presence of* 10 *cc.* 36 *per cent Acetic Acid.*

(*a*) To a solution containing 1 mgrm. C_2O_4 as $K_2C_2O_4$ were added 10 cc. of 36 per cent acetic acid and 10 cc. of $2N.CaCl_2$ in a total volume of 50 cc. The solution was heated to boiling and allowed to stand ten minutes. A white cloudiness was obtained. (*b*) To separate solutions, each containing 1, 2, 3, 4, 5, and 10 cc. respectively of F as NaF, 10 cc. of 36 per cent acetic acid and 10 cc. $2N.CaCl_2$ were added in a total volume of 50 cc. The solutions were heated to boiling and allowed to stand ten minutes. Negative results were obtained with 1—3 mgrms. F. With 4 mgrms. F a faint cloudiness was obtained, while 5—10 mgrms. F gave a decided cloudiness.

(To be continued).

THE CONSTITUTION AND STRUCTURE OF AN ATOM OF NITROGEN.

By HAWKSWORTH COLLINS.

Sir E. Rutherford has lately described experiments, from which he deduces that an atom of nitrogen is probably disintegrated in such a manner as to produce two atoms of hydrogen and a mass of 12.

In 1914 a mathematical proof that an atom of nitrogen is constituted by the union of two atoms of hydrogen with one of carbon was sent to the Nobel Institute of Sweden.

If Sir E. Rutherford's deduction turns out to be true this will be at least the fourth confirmation by direct experiment of a "Theory of the Constitution and Structure of the Chemical Elements," which was first produced in 1903.

The three other important confirmations are as follow:—

(A). Discovery by reasoning in 1903, and first printed in 1906:—	Discovery by direct experiment in 1913 by Prof. Soddy:—
The non-metallic nature of an element is always due to a pair or pairs of electro-positive forces, each pair emanating from a portion of the element of which the mass is 4, taking the mass of an atom of hydrogen as unity.	In an α-ray change, when a helium atom carrying two atomic charges of positive electricity is expelled, the element changes its place in the Periodic Table in the direction of diminishing mass and diminishing group number by two places.

The deduction on the left was obtained from the observation that—If a helium atom (at.wt. 4) carrying two charges of positive electricity could be expelled from several of the simple elements, the residual product would be two places lower in the Periodic Table, since each element would have lost two valences together with a mass of 4.

It was not known by direct experiment until about 1913 that helium has two electro-positive forces attached to it.

(B). Discovery by reasoning in 1903, sent to leading scientists in 1906, and first printed in 1910:—	Proof by direct experiment:—
An element, called H_3, was shown to be the chief constituent of all elements, being the only new element necessitated by this reasoning.	In 1913 Sir J. J. Thomson discovered X_3, which he considers is probably tri-atomic hydrogen, H_3, and which appears to be more stable than any known allotropic form of an element, and comes off from all kinds of substances.

(C). Discovery by reasoning in 1903, and first printed in 1910:—	Proof by direct experiment:—
The structure of neon was given as the combination of the structures of helium and oxygen.	In 1913 Messrs. Collie and Patterson formed neon by the union of helium and oxygen.

In 1911 the discovery of the exact relative volumes of the elements to two decimal places was made, the results bearing no resemblance to those of Kopp or of any other scientist, and were obtained from experimental data without the assistance (?) of any hypothesis whatever.

The results which concern the atom of nitrogen, and which were demonstrated in full in the communication to the Nobel Institute, are as follow:—

1. The relative volume of an atom of carbon at 15° C. in all carbon compounds in which the element is united only by single bonds to other elements is 0·71.
2. The relative volume of an atom of hydrogen at 15° C., when united to an atom of carbon in one particular position, which is called "the first position," is always 15·25.
3. The relative volume of an atom of hydrogen at 15° C., when united to an atom of carbon in another particular position, which is called "the fourth position," is always 5·76.
4. The relative volume of an atom of nitrogen at 15° C. when united only by single bonds to other elements, is 0·71.
5. The relative volume of an atom of nitrogen at 15° C., when united to an atom of carbon by three valences and in some other cases, is 15·96 = 0·71 + 15·25.
6. The relative volume of an atom of nitrogen at 15° C. in nitrates, nitrites, &c., is 21·72 = 0·71 + 15·25 + 5·76.

No one could possibly have guessed or hypothesised such a state of affairs, and then manipulated thousands of experimental data so that they fall into line in support of the hypothesis.

The above results show that two of the "hydrogen" constituents of nitrogen are capable of being expanded from negligible volume to 15·25 and 5·76 respectively.

If this represents the constitution and structure of an atom of nitrogen in the gaseous state, it is not surprising that collision with an α-particle should tear the two H-atoms from the main mass, for the volume occupied by these two constituents of nitrogen is about 30 times the volume of the remaining portion. The action would be comparable to the tearing away of a balloon by a sudden gust of wind from the hands of those who were holding it; the great strain on their arms being too sudden to given them an opportunity of overcoming the inertia of their bodies.

As several portions of the above-mentioned theory have now been proved to be true by direct experiment, it is practically certain that the whole of it is true, and that therefore, if scientists would make a serious study of it, further discoveries by direct experiment with regard to the constitution and structure of the chemical element would be facilitated.

THE ELECTROLYSIS OF SOLUTIONS OF THE RARE EARTHS. III.*

By L. M DENNIS and A. B. GRAY.

I. *Electrolysis of Neutral Solutions of the Nitrates of the Rare Earths.*

In a previous article upon this subject (Dennis and van der Meulen, *Journ. Am. Chem. Soc.*, 1915, xxxvii., 1963; Chemical News, cxix., 1) the fractional precipitation and separation of the rare earths by the electrolysis of aqueous solutions of their salts at voltages considerably higher than the decomposition values of these compounds were explained as probably due to the action of the hydroxyl ions, concentrated near the cathode, upon earths of different basicities, the hydroxide of the weakest base being precipitated first. If this explanation is correct, it follows that the selective precipitation of the hydroxides in the order of the basicities of the earths should proceed more evenly, and the separation of the earths be more complete, as the vigour with which the electrolyte is stirred is increased, because this would bring the hydroxyl ions more frequently into contact with the weakest bases and would thus tend to lessen the simultaneous precipitation of hydroxides of earths of different basicity.

With a view to gaining experimental evidence upon this point, two portions of a solution of certain rare earths were electrolysed under identical conditions, except that one solution was vigorously stirred, whereas the other was agitated just rapidly enough to keep the surface of the mercury cathode free from adherent deposit of the precipitated hydroxides. (For detailed description of the apparatus that was used for the electrolysis see Dennis and van der Meulen, *loc. cit.*).

The mixture of rare earths that was employed contained the yttrium and erbium groups and a trace of neodymium, but was free from thorium, cerium, and the more common elements. The average atomic weight of the earths in the mixture was 106·95. A neutral solution of the nitrates of these earths was prepared and was diluted with water until it contained 34 grms. of oxides to the litre. Two portions of this solution, of five litres each, were used for the electrolyses. The containers for the solutions were glass cylinders about 20 cm. in diameter. A layer of mercury about 1·5 cm. deep, which served as cathode, was placed in each cylinder, and this was covered with 5 litres of the solution of the earths. A porous cup 6 cm. in diameter and 15 cm. deep was suspended in the electrolyte and was filled to within one cm. of the height of the outer solution with a 10 per cent solution of nitric acid. The concentration of the acid in the cup was kept approximately constant during the electrolysis by fitting the cup with a constant-level syphon, and slowly dropping distilled water into the cup during the run. Agitation of the mercury cathode and of the solution was effected by air blown through glass tubes that dipped below the surface of the mercury. One cell was provided with two such air jets, the other with twelve. A sheet of platinum, inserted in the porous cup, served as anode.

The electrolysis was begun immediately after the porous cups were put in place and the anodes inserted. A current of three amperes was used and the electrolysis was continued until the amount of the hydroxides desired for the fraction had been precipitated.

The hydroxides precipitated in the two cells were distinctly different in character. Where the stirring had been slight, the hydroxides were granular and were easily collected on a filter. The precipitate in the cell in which the stirring had been vigorous was very finely divided, and could rapidly be separated from the liquid only by filtration through a pad of macerated filter paper with the aid of suction. Moreover, the precipitated hydroxides from this second cell were dark in colour because of the presence of finely divided mercury. We observed no indication of the formation of an amalgam of the rare earths, thus confirming the statement of Kettembeil (*Zeit. Anorg. Chem.*, 1904, xxxviii., 213).

When an amount of the rare earth hydroxides desired for one fraction had been precipitated, the current and air blast were turned off, and the porous cups were removed from the cells. The solution in each cell was syphoned off and was then filtered on a Büchner funnel to remove the suspended hydroxides. The mercury and the hydroxides still remaining in the cell were transferred to a separatory funnel, the mercury was drawn off, and the hydroxides were then brought upon the filter. The precipitate was thoroughly washed with water and was then treated with warm 2 N hydrochloric acid, which quickly dissolved the hydroxides but left most of the finely divided mercury undissolved. Hydrogen sulphide was passed through the filtrate to remove the slight amount of mercury that had been dissolved, the solution was again filtered, the hydrogen sulphide was removed by boiling, and the rare earths were precipitated by oxalic acid. The oxalates were washed with hot water until free from chlorides and were then dried at 100°.

The residual solution from which the precipitated hydroxide has thus been removed, together with the wash water which had been evaporated to small bulk, were returned to the cell and the electrolysis was continued until a second fraction of the rare earth hydroxides had been precipitated. This precipitate was removed and purified as before, and electrolysis was repeated until nine fractions had been obtained. The rare earths still remaining in solution were then precipitated by oxalic acid.

The atomic weight of each fraction was determined by the oxalate-oxide method. The absorption spectrum of each fraction was studied with the aid of a Krüss spectroscope, and the relative intensities of distinctive bands were approximated by the method of Dennis and Bennett. (*Journ. Am. Chem. Soc.*, 1912, xxxiv., 7). A neutral solution of the chlorides of the earths, containing 5 grms. of the oxides in 25 cc., was employed in each spectroscopic examination.

The data obtained in these two series of electrolyses are given in Tables I. and II.

The atomic weights of the various fractions and the relative intensities of the distinctive absorption bands of the "coloured" earths in the fractions are plotted in Figs. 1 and 2. The spacing of the fractions along the axis of abscissas is based upon the actual weights of the several fractions.

Comparing the results of the two series of electrolyses it will be noted that as the vigour of stirring of the catholyte is increased, there results a somewhat more rapid

* This article is a summary of a portion of the thesis presented to the Faculty of the Graduate School of Cornell University by A. B. Ray in partial fulfilment of the requirements for the degree of Doctor of Philosophy. From the *Journal of the American Chemical Society*, xl., No. 1.

segregation of the earths of higher atomic weights in the first fractions and a better concentration of the earths of lowest atomic weight (chiefly yttrium) in the last fractions. Vigorous stirring also accelerates in the precipitation of erbium, holmium, and thulium, which results in a higher concentration of neodymium (and yttrium) in the last fractions. A third series of electrolyses in which the stirring was still more rapid showed further accentuation of the differences.

Table I.

Cathode area—452·4 sq. cm.
Atomic weight of original mixture—106·95.
Catholyte stirred vigorously by means of 12 air jets.

Number of fraction.	Atomic weight.	Weight of oxides (grms.).	Ampere hours.	Volts.
1	121·84	19	34·5	7
2	114·80	18·68	27	7
3	112·24	22·16	27	7
4	108·77	17·12	22	7·4
5	105·85	14·42	22	7·6
6	103·15	10·06	18·5	8
7	100·82	12·32	19	9
8	97·58	11·80	22	11
9	94·68	14·50	22	15
10	95·58	2·02	Pptd. by oxalic acid	

described, the hydroxides of the earths are precipitated in the order of their basicities, and their separation is the more complete the more vigorously the mercury cathode and the catholyte are stirred (R. J. Meyer, Abegg's "Handbuch der Anorganischen Chemie," iii., 147).

II. *Electrolysis of Neutral Solutions of the Nitrates of the Rare Earths and Thorium Nitrate.*

The weakly basic character of thorium seemed to render it probable that electrolysis of a solution containing thorium nitrate and nitrates of the rare earths might result in the rapid concentration of thorium in the early fractions. Thorium for commercial uses is now extracted on a large scale (about 300,000 kgrms. of thorium nitrate per annum) from monazite. For this reason the electrolytic separation of thorium from the earths with with it is associated in monazite, possessing as it does a practical interest, was investigated. The mixture of the rare earths was prepared from the by-product of the technical separation of thorium from monazite. This material was carefully purified and was freed from cerium and thorium. The earths were converted to the oxides, and from this mixture of the oxides a neutral solution of the nitrates was prepared. The concentration of the solution was then determined by precipitation with oxalic acid and ignition of the oxalate to oxide.

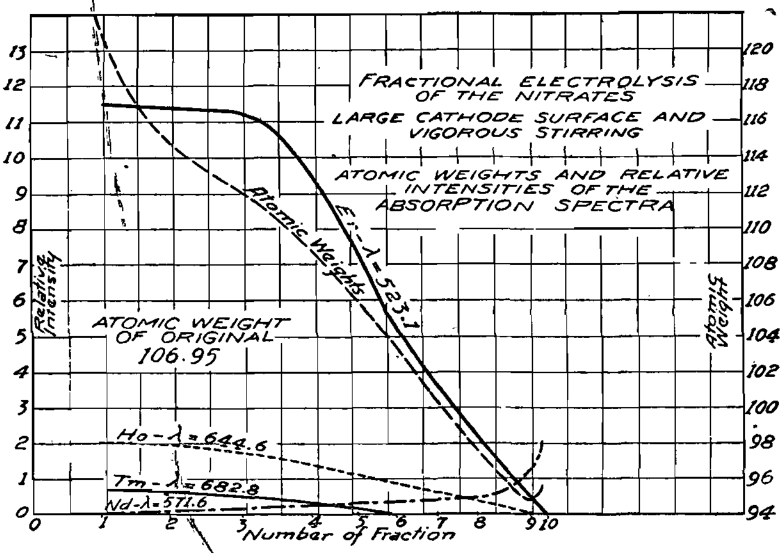

Fig. 1.

Table II.

Cathode area—452·4 sq. cm.
Atomic weight of original mixture—106·95.
Catholyte slightly stirred by means of two air jets.

Number of fraction.	Atomic weight.	Weight of oxides (grms.)	Ampere hours.	Volts.
1	119·61	25·56	34·5	7
2	112·27	25·20	27	7
3	111·42	19·44	27	7
4	105·85	23·30	22	7·4
5	105·22	17·94	22	7·8
6	101·21	13·56	18·5	8·2
7	100·20	13·26	19	9
8	97·10	13·98	22	11
9	96·00	10·36	22	15
10	98·20	1·54	Pptd. by oxalic acid	

These results show, therefore, that when a neutral nitrate solution of the rare earths here indicated is fractionally electrolysed with a diaphragm in the manner

A clear, neutral solution of thorium nitrate was prepared by adding pure, moist thorium hydroxide to cold, dilute nitric acid until the hydroxide was in excess, and then allowing the material to stand until a test with Congo-red paper showed the absence of free acid. The solution was then separated from the undissolved hydroxide, and its concentration was determined.

The electrolysis was conducted in the manner already described, very vigorous stirring of the catholyte and mercury cathode being employed.

(a) *Electrolysis of Solutions of Thorium Nitrate.*—Electrolyses of solutions of thorium nitrate alone were first made to ascertain whether the precipitation of the hydroxide may most satisfactorily be made from cool or from hot solution. The electrolyses were made in two cells, connected in series. The solution in one cell was kept at 22° during the run; that in the second cell at about 90°. A dilute solution of thorium nitrate (1·3 grms. ThO_2 in 100 cc.) was placed in each cell. The electrolysis was conducted as before described, a current of two

amperes being employed. The voltage across the cold cell rose from 6 volts at the beginning to 40 volts at the end of the run; that across the warm cell, from 5 volts to 30 volts. The current required for practically complete precipitation in the cold cell was 5 ampere hours; in the warm cell, 4·75 ampere hours. The current required by theory for complete precipitation was 4 ampere hours. This showed a current efficiency in the cold cell of 80 per cent; in the warm cell of 84·2 per cent. The precipitate of thorium hydroxide in the cool cell was granular, was easily filtered and washed, and contained almost no finely divided mercury. The thorium hydroxide thrown down in the warm cell was flocculent, contained much finely divided mercury, and was filtered and washed with difficulty.

From these results it was apparent that the electrolysis of a solution of thorium nitrate operates most satisfactorily when conducted at about room temperature.

To determine the influence of the concentration of the electrolyte upon the character of the precipitate, three solutions of thorium nitrate containing 0·5 per cent, 5 per cent, and 20 per cent of thorium dioxide, respectively, were electrolysed in small cells of about 300 cc. capacity. The thorium hydroxide precipitated from the 20 per cent solution in very finely divided form resembling a colloidal solution. The character of the precipitates in the other

Angew. Chem., 1902, xv., 303), the solution was then heated to from 60–80°, and an excess of 10 per cent hydrogen peroxide was added. Thorium is thus quantitatively precipitated as the hydrated peroxide, the rare earths remaining in solution (Meyer and Hauser, "Die Analyse der Seltenen Erden und der Erdsäuren," p. 250). The precipitate was collected on a filter, thoroughly washed, and then dissolved in 2 N hydrochloric acid. The solution was diluted to one litre and 25 cc. portions were precipitated by ammonium hydroxide, and the thorium hydroxide ignited to the oxide, and weighed.

The filtrate from the first thorium precipitation by hydrogen peroxide was diluted to 500 cc., 25 cc. portions were precipitated by oxalic acid, and the oxalates of the rare earths were ignited to oxides and weighed.

The filtrate from the first fractional precipitate of the hydroxide, together with the wash water, were returned to the cell and electrolysed as before. The procedure was again repeated, three fractional precipitations in all being made. The results are set forth in Table III.

The results show that fractional electrolysis effects a marked concentration of thorium in the early fractions, from about 15 per cent in the original mixture to over 78 per cent in the first fraction, and nearly 35 per cent in the second fraction.

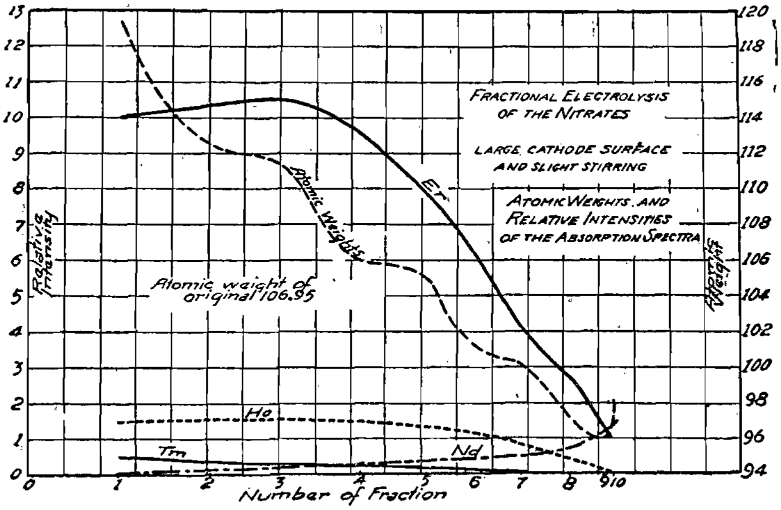

FIG. 2.

two cells showed that as the concentration of the solution is lowered (down to 0·5 per cent) the granular form of the hydroxide becomes more pronounced. Because of these results the later electrolyses of mixtures of thorium nitrate and the nitrates of the rare earths were made with solutions that contained about 0·5 grm. thorium dioxide per 100 cc.

(b) *Electrolysis of Solutions containing Thorium Nitrate and Nitrates of the Rare Earths.*—A solution containing, in 3·5 litres, 14·72 grms. of thorium oxide and 85 grms. of the oxides of the rare earths (av. at. wt. 140·5) was electrolysed with a current of one ampere. The mercury cathode was vigorously stirred during the electrolysis and the concentration of the acid in the porous cup was kept practically constant. At the end of six hours the electrolysis was interrupted and the precipitated hydroxides were collected and purified in the manner already described. The hydroxides were then dissolved in 2 N nitric acid, an excess of acid being avoided. To this solution there was added one-fifth of its volume of a concentrated solution of ammonium nitrate (Benz., *Zeit.*

TABLE III.

Volume of electrolyte, 3·5 litres. Total amount ThO_2 and R_2O_3 present in the solution = 99·72 grms., of which ThO_2 = 14·72 grms. (14·76 per cent), R_2O_3 = 85·00 grms. (85·24 per cent). Average atomic weight of rare earths = 140·5. Current = one ampere.

Fraction number.	Ampere hours.	Wt. in grms. ThO_2.	Wt. in grms. R_2O_3.	Per cent. ThO_2.	Per cent. R_2O_3.
1	4	5·048	1·372	78·63	21·37
2	6	3·94	7·40	34·75	65·25
3	7	2·22	8·88	20·0	80·0

Another electrolysis was run to determine to what degree thorium would be concentrated in the first fraction when it was associated with the monazite earths in approximately the ratio in which it occurs in that mineral. A neutral solution of the nitrates containing 5·95 grms. of thorium oxide and 112·85 grms. of the rare earth oxides (av. at. wt. = 140·5) was diluted to 6·25 litres and electrolysed as before with a current of one ampere.

TABLE IV.

Fraction number.	Ampere hours.	Wt. in grms. ThO_2.	Wt. in grms. R_2O_3.	Per cent. ThO_2.	Per cent. R_2O_3.
1	3	1·53	1·44	52	48

From these results it is seen that a single fractional electrolysis of three hours' duration precipitates nearly 26 per cent of the thorium present, and that the precipitated hydroxides contain 52 per cent of ThO_2 as against 5 per cent in the original mixture.

CHEMICAL ACTION PRODUCED BY RADIUM EMANATION. I.*

THE COMBINATION OF HYDROGEN AND OXYGEN.

By S. C. LIND.

(Continued from p. 19).

4. *The Course of the Reaction.*

A KINETIC equation was previously deduced by the writer (*Journ. Phys. Chem.*, 1912, xvi., 592) for gaseous reactions being produced by radium emanation in fixed volume when accompanied by change in pressure. It was assumed that for a given gaseous mixture maintaining constant composition during reaction, the rate of action would depend on two variables only, the pressure and the quantity of emanation present. The integrated form of the kinetic equation was—

$$k\mu/\lambda = \text{constant} = (\log P/P_0)/(E_0[e^{-\lambda t}] - 1) \quad . \quad 1.$$

The constancy of the first term $k\mu/\lambda$ holds only for a gaseous mixture in which the specific ionisation remains constant during the reaction. The numerical value of $k\mu/\lambda$ also depends on the volume of the reaction bulb. The definition of the terms of $k\mu/\lambda$ will be given later; for the present purposes it may be regarded only as a velocity of reaction *constant*. P_0 and P are respectively the initial pressure and that at any time t expressed in millimetres of mercury, E_0 is the initial emanation expressed in curies, which is decaying proportionally to the factor $e^{-\lambda t}$ to be found in the Kolowrat table for radium emanation (*Le Radium*, 1910, vi., 195; Mdme. Curie, "Traité de Radioactivité," ii., 361; *Chemiker Kalendar*, 1914, ii., 361; Rutherford, "Radio-active Substances and their Radiation," 1913, p. 665).

The actual course of the reaction in spherical bulbs of several different sizes can be seen in Table I., in which the application of Equation 1 is to be found in the last column.

The degree of constancy is satisfactory, and proves that the velocity of reaction in a given volume depends only on the two variables mentioned above, the quantity of emanation and the pressure of the gas. This test of Equation 1 is far more rigid than the one earlier obtained (S. C. Lind, *loc. cit.*) with the data of Cameron and Ramsay, in whose experiments the total change of pressure was frequently quite limited, owing to the small quantities of emanation employed.

It will be observed by comparing Cols. 4 and 5 that the percentage of reaction completed runs well ahead of the percentage of emanation decayed, but it approaches it as the quantity of gas to be acted on is increased and the quantity of emanation decreases. Notice that in the case of very fast reactions where the quantity of gas is small and the quantity of emanation high, half of the chemical reaction is completed in 1½ days, or less; and only in reactions where the quantity of gas to be acted on is relatively large and the quantity of emanation small, and hence the total change in pressure very slight, would the limiting case be approached that would agree with the rate claimed by Cameron and Ramsay, proportional to the decay of emanation with a half period of three days and twenty-one hours. This case is illustrated by the cylinder with very low emanation, chosen purposely to parallel Cameron and Ramsay's conditions and shows how the limiting case can be attained with the limits of experimental precision.

The reaction can come to an end by approximate exhaustion of either the emanation or the reacting gases; the former takes place in small bulbs with high emanation, the latter in larger bulbs. The actual final pressure after decay of all the emanation may be calculated from Equation 1 for any given case.

TABLE I.—*Velocity of Reaction* $2H_2+O_2=(2H_2O)$ *at Constant Volume in Bulbs of various Diameters and Values of Constant* $k\mu/\lambda$. (Equation 1).

2 cm. Sphere.

Vol. = 3·738 cc. Exact diam. = 1·925 cm. E_0 = 0·1464 curies.

Time. Days.	Time. Hours.	P mm. Hg.	Volume decrease. Cc.	Per cent reaction completed.	Per cent Em. decayed.	$k\mu/\lambda$ (constant).
0	0	436 6	0	0	0	—
0	4·83	387 8	0·2400	11·18	3·56	22·8
0	8·58	358·0	0·3866	18·00	6·23	21·8
1	0·75	248·0	0·9276	43·30	16·94	22·8
1	7 67	216·8	1·081	50·34	21·14	23·1
2	0·00	155·2	1·384	64·45	30·23	23·3
2	7·67	141·2	2·453	67·66	34·13	22·6
3	0·25	111·9	1·597	74·35	41·83	22·2
4	0·58	69·7	1·805	84·05	51·53	24·3
6	0·08	42·6	1·937	90·24	66·06	24·0
8	6·00	30·4	1·997	93·03	77 35	23·5
				Average		23·04

3 cm. Sphere.

Vol. = 13·272 cc. Exact diam. = 2·924 cm. E_0 = 0·1682 curies.

Time. Days.	Time. Hours.	P mm. Hg.	Volume decrease. Cc.	Per cent reaction completed.	Per cent Em. decayed.	$k\mu/\lambda$ (constant).
0	0	584·6	0	0	0	—
0	20·17	466 6	2·043	24·52	14·04	9 54
1	4·67	424·1	2·802	33·63	19·35	9·86
1	20·25	371·8	3·715	44·60	28·24	9·51
2	3·75	341·7	4·241	50·91	32·17	9·93
2	20·00	296·6	5·029	60·37	39·95	10·10
3	9·50	272·6	5·449	65·40	45·73	9·93
3	23·42	249·8	5·845	70·17	51·11	9·89
5	21·17	197·1	6·767	81·23	65·31	9·90
8	0·75	161·7	7·384	88·63	76·44	10·00
11	0·00	142·0	7·729	92·76	86·19	9·77
14	23·50	115·4	8·194	98·35	93·25	10·35
22	3·17	111·4	8·264	99·19	98·14	10·06
30	2·75	107·5	8·332	100·00	99·56	10·19
				Average		9·92

4 cm. Sphere.

Vol. = 32·58 cc. Exact diam. = 3·963 cm. E_0 = 0·1396 curies.

Time. Days.	Time. Hours.	P mm. Hg.	Volume decrease. Cc.	Per cent reaction completed.	Per cent Em. decayed.	$k\mu/\lambda$ (constant).
0	0	437·1	0	0	0	—
0	20·67	391·1	1·972	20·29	14·36	(5·55)
1	20·50	353·8	3·572	36·73	28 65	5·29
2	20·75	324·7	4·818	49·56	40·29	5·29
4	0·0	297·3	5·995	61·66	51·33	5·38
5	20·33	268·9	7·211	74·16	65·87	5·28
6	23·75	247·6	8·127	83·58	76·96	5·29
9	22·58	235·8	8·630	88·76	83·29	5·31
12	20·50	222·6	9·196	94·58	90·11	5·37
15	3·50	220·5	9·287	95·52	93·45	5·25
20	2·50	214·5	9·545	98·17	97·32	5·24
31	1·00	210·3	9·723	100·00	99 62	5·26
				Average		5·30

* Published with permission of the Director of the U.S. Bureau of Mines. From the *Journal of the American Chemical Society*, xli., No. 4.

Time. Days.	Hours.	P mm. Hg.	Volume decrease. Cc.	Per cent reaction completed.	Per cent Em decayed.	$k\mu/\lambda$ (constant).
			5 cm. Sphere.			
Vol. = 61·321 cc. Exact diam. = 4·893 cm. E_0 = 0·1640 curies.						
0	0	557·7	0	0	0	—
0	18·13	518·8	3·138	17·36	12·71	3·47
1	1·50	506·7	4·115	22·76	17·41	3·36
1	18·50	478·9	6·357	35·17	27·29	3·40
2	2·25	467·0	7·318	40·48	31·40	3·45
2	18·08	445·3	9·067	50·16	37·08	3·51
3	1·67	437·9	9·668	53·47	42·45	3·47
3	20·92	416·1	11·42	63·19	50·19	3·56
5	18·17	386·4	13·82	76·43	59·52	3·76
7	18·25	362·6	15·74	87·06	70·26	3·73
12	22·50	333·6	18·08	100·00	90·26	3·47
				Average		3·52
			5½ cm. Sphere.			
Vol. = 92·604 cc. Exact diam. = 5·613 cm. E_0 = 0·2078 curies.						
0	0	504·4	0	0	0	—
0	21·08	465·6	4·728	18·77	14·63	2·64
1	15·58	433·9	8·590	34·10	25·68	2·82
1	23·50	425·2	9·215	36·59	29·97	2·74
2	15·33	407·1	11·85	47·07	37·81	2·73
2	23·25	397·7	13·00	51·62	41·39	2·76
3	15·58	384·8	14·57	57·86	48·15	2·71
4	16·83	365·6	16·91	67·16	57·10	2·72
6	0·33	350·2	18·79	74·59	66·12	2·62
6	15·17	344·5	19·48	77·36	69·61	2·64
7	20·42	334·0	20·76	82·41	75·66	2·62
9	19·58	321·5	22·28	88·47	92·91	2·62
14	15·33	305·2	24·28	96·36	92·79	2·61
22	21·25	297·7	25·19	100·00	98·37	2·58
				Average		2·68
			Cylinder 4 cm. long, 1·8 cm. diam.			
Vol. = 6·787 cc. Diam. of equiv. sphere = 2·375 cm. E_0 = 0·01219 curies.						
0	0	578·1	0	0	0	—
0	23·00	562·6	0·1385	15·88	15·84	14·1
2	0·0	549·5	0·2555	29·31	30·23	14·1
3	22·00	527·9	0·4480	51·44	50·58	14·7
5	4·00	517·7	0·5394	61·89	60·54	14·9
7	22·75	505·1	0·6519	74·80	76·08	14·6
12	1·00	491·5	0·7734	88·74	88·55	15·4
18	22·00	484·0	0·8405	96·42	96·37	15·1
30	2·00	480·5	0·8716	100·00	99·54	15·2
				Average		14·8

While the ratio of emanation to gas affects greatly the actual velocity of the reaction it does not influence the constancy of $k\mu/\lambda$, thus proving that the kinetic equation applies in all cases. The ratio of radium emanation to reacting gases may rise continuously as in small bulbs, may pass through a maximum as in 3 cm. bulbs, or may fall continuously as in larger bulbs without affecting the constancy. However, for reasons to be brought out in Part II., the gas pressure may not fall too low in a small (1—2 cm.) bulb without affecting the velocity constant, due to action of the "recoil atoms."

Experiments with and without drying agent show, in agreement with Cameron and Ramsay, that the presence of moisture does not influence the velocity of the reaction. However, in larger bulbs starting with dry gases and no drying agent, some time would be required to saturate the gases with water-vapour, which would lead to unnecessary complications in applying the kinetic equation during this period, which are best avoided by having drying agent present in the reaction bulb.

The question of chemical equilibrium in the reaction between hydrogen and oxygen has recently been considered by the writer in another paper (*Am. Electrochem. Soc.*, 34th General Meeting, Advance Copy No. 5), where it was shown that the equilibrium in some cases can attain 99 per cent of the total combination of the hydrogen and oxygen. This is mentioned here to show that it is not necessary to consider the possibility that either hydrogen or oxygen is removed by side reactions permanently from the main reaction. Although Scheuer (*loc. cit.*) has reported the formation of some hydrogen peroxide it is evident that its formation must be of somewhat temporary nature, and that the reaction later proceeds to the practically complete formation of water.

(To be continued).

SOLDERS FOR ALUMINIUM.

THE following general conclusions concerning Aluminium Solders have been issued by the Bureau of Standards, Washington, U.S.A. :—

1. All metals or combinations of metals used for aluminium soldering are electrolytically electronegative to *aluminium*. A soldered joint is therefore rapidly attacked when exposed to moisture and disintegrated. There is no solder for aluminium of which this not true.

2. Joints should therefore never be made by soldering unless they are to be protected against corrosion by a paint or varnish, or unless they are quite heavy, such as repairs in castings, where corrosion and disintegration of the joint near the exposed surface would be of little consequence.

3. Solders are best applied without a flux, after preliminary cleaning and tinning of the surfaces to be soldered. The composition of the solder may be varied within wide limits. It should consist of a tin base with addition of zinc or of both zinc and aluminium, the chief function of which is to produce a semi-fluid mixture within the range of soldering temperatures.

Suggested Ranges of Composition.

Tin-zinc solders—	
Tin	Remainder
Zinc, per cent	15—50
Tin-zinc-aluminium solders—	
Tin	Remainder
Zinc, per cent	8—15
Aluminium, per cent	5—12

4. The higher the temperature at which the "tinning" is done the better the adhesion of the tinned layer. By using the higher values of the recommended zinc and aluminium percentages given above, the solder will be too stiff at lower temperature to solder readily, and the workman will be obliged to use a higher temperature, thus securing a better joint. A perfect union between solder and aluminium is very difficult to obtain.

5. The joint between previously tinned surfaces may be made by ordinary methods and with ordinary soft solder. Only the "tinning" mixture need be special for aluminium.

6. There is no reason why a good solder for aluminium need be brittle as several commercial varieties are, and it is very undesirable that it should be.

7. The tensile strength of a good aluminium solder is about 7000 pounds per square inch. The strength of a joint depends upon the type and upon the workmanship. Much dependence should not be placed on the strength of a joint.

MEXICAN "VEGETABLE WOOL."—Considerable interest has been shown of late in the fibre known as "pochote" in Mexico and "Java kapok" in the United States. This product has been known and used by the natives of Mexico for many years.

NOTICES OF BOOKS.

The National Organic Colouring Matters. By Arthur George Perkin, F.R.S., F.R.S.E., F.I.C., and Arthur Ernest Everest, D.Sc., Ph.D., F.I.C. London, New York, Bombay, Calcutta, and Madras: Longmans, Green, and Co. 1918. Pp. xxii+655. Price 28s. net.

This treatise provides an admirable survey of a subject which has not been adequately treated by any book in the English language, since the appearance forty-five years ago of Sir William Crookes' "Handbook of Dyeing and Calico Printing." Very considerable advances in our knowledge of the chemistry of natural dyes have been made since 1874, and a complete account of the results of modern researches will be of great value to investigators and students. The natural colouring matters are nowadays being more extensively used than heretofore for colouring articles of food, and their production in the pure state may develop into a comparatively important industry. There is plenty of scope for research work on the dyes of unknown composition, and the treatise contains many suggestions of profitable lines of study, while it provides also a most comprehensive account of all that has already been done. The authors' knowledge of their subject it is unnecessary to say is quite unrivalled, and their investigations have extended to many of the natural groups. The various dyeing materials are classified according to the constitution of their chief constituents, and a detailed account is given of all the most important representatives of each of the 17 groups, while not the least important chapter is that on the natural dyes of unknown constitution.

NOTES.

The May number of the *Journal Chimie et Industrie*, the organ of the Société de Chimie Industrielle, contains an exceedingly interesting article decribing the visit of the members of the Inter-Allied Conference of Associations of Pure and Applied Chemistry to Chauny, which visit was made at the invitation of the Compagnie des Produits Chimiques de Saint-Gobain. This company was the owner of some of the oldest chemical factories in France, situated at Chauny, which are now nothing but a mass of ruins. A special train from Paris was placed at the disposal of the guests, and *déjeuner* was served in the restaurant cars attached to the train. Chauny was reached at 11 o'clock, and the members of the party were immediately conducted round the ruined factories by the president, vice-president, and other officials of the Société de Saint-Gobain. The products manufactured before the war included sulphuric and hydrochloric acids, sodium sulphate, chlorine, and various artificial manures, as well as smaller quantities of nitric acid, sodium fluosilicate, &c. The Germans reached Chauny on September 1, 1914, and at once began systematically to remove all the materials and to destroy the buildings and apparatus. All the lead chambers were demolished and the lead requisitioned, as well as copper cables, &c. The illustrations with which the article is provided give some idea of the state of devastation produced, and it is only too evident that the work of reconstrucrion will be tedious, dangerous, and very costly; it is well to remember that in the meantime German products will be manufactured with comparative ease and will be put upon the markets in abundance.

The monthly periodical *Le Radium*, published by Masson et Cie., of Paris, has now resumed publication after an interruption lasting nearly five years, and we offer the editor and staff our heartiest congratulations and good wishes for a prosperous and useful future. Unhappily the founder of the paper, M. Jacques Danne, has recently died, and the May number contains a short sketch of this life and work. There are also an original article on ionisation by collision, and translations of articles from English and German periodicals, together with short analyses of papers on radio-activity and radiation which have appeared recently, and a complete bibliography, beginning with the year 1914.

Federation of British Industries.—H.M. the King granted an audience on the 10th inst. at Buckingham Palace to Dr. Pandia Calogeras, one of the Brazilian delegates at the Peace Conference and representative for Brazil on the League of Nations Council. Doctor and Mdme. Calogeras proceed to Edinburgh to join the Brazilian Commercial Delegation which is now visiting various industrial centres of Great Britain under the auspices of the Federation of British Industries. It will be remembered that Dr. Calogeras was chosen by the Brazilian Government as Head of the Commercial Delegation. The following resolution has been passed by the Executive Committee *re* Nationalisation:—"A special Committee of the Federation of British Industries has for some time been considering the question of Nationalisation of industry, and it is hoped that a reasoned and full report will shortly be ready for submission. In the meantime this meeting of the Executive Committee of the Federation of British Industries reaffirms the resolution adopted by the Grand Council on May 14, 1919, viz., 'That this Grand Council expresses its unanimous opinion against the principle of nationalisation of industry.'"

British Scientific Products Exhibition.—At the Central Hall, Westminster, a series of kinematograph films of scientific and technical interest were shown in the Great Hall on the following dates:—Tuesday, July 8; Thursday, July 10; Tuesday, July 15; Thursday, July 17. These will be continued (3.30 to 5.30 p.m.) on Saturday, July 19; Tuesday, July 22; Thursday, July 24; Saturday, July 26; Tuesday, July 29; Thursday, July 31. The films illustrate—Aircraft Construction and Utilisation; The Making of a Big Gun; The Water Powers of Canada and their Industrial Utilisation; Wireless Telegraphy and Telephony; Magneto Construction. The following lectures were delivered in Committee Room B:—Monday, July 7—"Chemistry in Reconstruction," by Sir William Tilden, F.R.S. Wednesday, July 9—"Sound under Water and its Applications," by Prof. W. H. Bragg, F.R.S. Friday, July 11—"Coal Conservation," by Prof. H. E. Armstrong, F.R.S. Monday, July 14—"Progress in Rangefinders," by Prof. Archibald Barr. Friday, July 18—"Explosives," by J. Young, of the Royal Military Academy. The following further lectures will be delivered (at 5.30 p.m.):—Monday, July 21—"Progress in Aviation during the War Period," by L. Bairstow, F.R.S. Wednesday, July 23—"How the Cotton Plant Feeds as well as Clothes us," by S. E. de Segundo. Friday, July 25—"A Few Thoughts on the Development of London," by Raymond Unwin, F.R.I.B.A. Monday, July 28—"Scientific Lighting and Industrial Efficiency," by L. Gaster. Wednesday, July 30—"Recent Progress in Bee-Keeping," by W. Herrod Hempsall. Friday, August 1—"Applications of Science to Military Mining," by H. Standish Ball.

British Industries Fair (Glasgow), 1919, Postponed until 1920.—The Committee of the Glasgow Corporation who have charge of the arrangements for the British Industries Fair to be held within the Kelvin Hall of Industries in September next, have decided to postpone the show until February of next next. This decision was only arrived at after a great deal of serious consideration, and has been brought about largely by the declaration of Peace. The arrangements for the September Fair were well in hand long before the Armistice was signed. Following the cessation of hostilities the Board of Trade (with whose authority and support the Fair is held) decided

that the British Industries Fairs (1920) would be held simultaneously in London, Birmingham, and in Glasgow from February 23 till March 5, 1920. The close proximity of two fairs in Glasgow, September and February, was discussed at some length by a large number of exhibitors who have booked space for the September show. The result of their deliberations was that they made the suggestion to the Committee of the Glasgow Corporation that the September Fair should be postponed and their efforts concentrated on the February show. In view of the fact that special arrangements were being made by the Board of Trade to bring foreign buyers to next year's Fair, it was considered disadvantageous from an exhibitor's point of view to have two shows at Glasgow within a few months of each other, and that the one Fair which would be a specially strong one would be sufficient. These considerations led the Corporation Committee to come to their decision to agree to the exhibitors' suggestion, and a circular has now been issued stating that the September Fair at Glasgow has been postponed until the Spring. The classification of exhibits for the February enterprise as Glasgow will as in the past include the following:—Textiles of all descriptions; Ready made clothing, including hosiery; Hats and caps; Boots, shoes, and gloves; Carpets and upholstery material; Foodstuffs prepared and preserved; Chemicals (light and heavy); Domestic chemical products; Cardboard boxes.

Liebig's Extract of Meat Company, Ltd.—At a recent Board meeting it was resolved that, subject to confirmatiou at the 54th Ordinary General Meeting of the Company to be held on July 24, an additional dividend of 10 per cent and a bonus of 5s. per share, both free of income-tax, on the Ordinary Shares for the year ended March 31, 1919, will be payable on and after July 25 to proprietors who are registered on the Company's books on July 12 and to holders of Ordinary Share Warrants to Bearer.

NOTES FROM FOREIGN SOURCES

Researches on the Chemical Action in Lead Accumulators.—Ch. Féry.—The action of a lead accumulator is analogous to that of an ordinary pile; it is due to the attack of the negative, giving a plumbous sulphate, Pb_2SO_4, which is almost black in colour and corresponds to the plumbous oxide Pb_2O which is already known to chemists. Depolarisation is due to the reduction to PbO_2 of a peroxide of formula Pb_2O_5, which may be regarded as the anhydride of perplombic acid. This substance is black in colour, endothermic, and a powerful oxidiser. Its resistibility is 22 times less than than of PbO_2. It is reduced by dry hydrogen with rise of temperature, production of PbO_2, and liberation of water vapour. The chemical reactions which occur during the charging and discharging of the accumulator may be represented by $Pb_2 + H_2SO_4 + Pb_2O_5 \rightleftharpoons Pb_2SO_4 + H_2O + 2PbO_2$. The plumbous sulphate formed during the normal discharge is very rapidly transformed in air to the white sulphate, owing to the presence of sulphuric acid—$Pb_2SO_4 + H_2SO_4 + O = PbSO_4 + H_2O$. Hence a discharged battery must not be allowed to stand.—*Bull. Soc. Chim. de France*, 1919, xxv.-xxvi., 223.

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Assistant Metallurgical Chemist (21) requires Situation. Experience in both Ferrous and Non-ferrous Analyses, Case-hardening, Heat Treatment, Mechanical Testing, and Metallography.—Address, A. M. C., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist, three years' experience in large Tar Products Works before taking active service, now demobilised, desires Employment in London or the Provinces.—Address, T. T., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist (French) seeks Situation. Ten years' practice in Analysis in Research Laboratory. Specialist in Bauxite-Aluminium and Ores. Speaks fluently English, French, and German.—Address, "Frenchman," Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted, Chemist with knowledge of Metallurgy for Experimental Laboratory near London. Give full particulars and salary required.—Address, C. M., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Wanted (Midland district), Research Chemists with first-class Academic training. Must be well up in Organic preparations, good manipulators, and capable of carrying on investigations under the direction of the Chief. Both Senior and Junior Chemists (male or female) are required, who have completed University course. Good prospects. Commencing salary according to abilities and experience.—Address, "Midland," Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

FOR SALE, two pairs PLATINUM WIRE GAUZE ELECTRODES (weight of Electrodes 4 ozs. Troy), with Stand for rotating to hold 3 set Electrodes.—Offers for above to F. A. Craig, Ard-Cluan, Waterside, Londonderry.

LABORATORY wanted in London, with or without ANALYTICAL PRACTICE. Send particulars.—Address, "Bunty," Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Process for Separating Glutamic Acid from other Amino-acids. No. 106081.

Process of Recovering Sulphuric Acid from the Waste Acid of Petroleum Factories. No. 12363 of 1915.

The Owners of the above PATENTS are desirous of arranging, by Licence or otherwise, on reasonable terms, for the Commercial development of the Inventions.
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THE CHEMICAL NEWS

VOL. CXIX., No. 3095.

A SYSTEMATIC PROCEDURE FOR THE DETECTION OF THE ACIDS OF GROUP I.*

By LOUIS J. CURTMAN and DAVID HART.

(Concluded from p. 29).

IV.—*Detection of Sulphite by Oxidation to Sulphate and Precipitation as* $BaSO_4$.

Use of Br *Water.*—To separate solutions containing respectively 1, 2, and 3 mgrms. SO_3 as Na_2SO, 45 cc. HCl (1 : 2) were added and 5 cc. 2N.$BaCl_2$, making a total volume of 50 cc. Any precipitates which formed were filtered off and to the filtrates bromine water added drop by drop till the solutions assumed a permanent yellow colour. The solutions were then boiled until all the Br was given off and allowed to stand five minutes. In each case a white ppt. was formed. It was suspected, however, that oxalates might be partly destroyed by bromine water and thus make it necessary to use some other oxidising agent. To ascertain this information the following experiments were made :—To separate solutions containing respectively 25 and 50 mgrms. C_2O_4 as $K_2C_2O_4$, 45 cc. HCl (1 : 2) and 5 cc. 2N.$BaCl_2$ were then added. Br water was added until a permanent yellow colour was imparted to the solutions. These were boiled and concentrated to 25 cc., made alkaline with NaOH, then acid with acetic acid. 10 cc. of 36 per cent acetic acid and 10 cc. 2N.$CaCl_2$ were then added. A precipitate was obtained with 50 mgrms. C_2O_4, but none with 25 mgrms. C_2O_4. Thus bromine is unsuitable for the oxidation of sulphites to sulphates because it destroys considerable amounts of oxalates at the same time.

Use of H_2O_2.—Since H_2SO_4 and H_3PO_4 are generally employed in the manufacture of H_2O_2 it was necessary for our purpose to make use of H_2O_2 which was found to be practically free from SO_4 and PO_4. Mallinkrodt's 3 per cent H_2O_2 was found suitable for our work as shown by the following test :—To 20 cc. 3 per cent H_2O_2 5 cc. of 2N.$BaCl_2$ were added. A faint cloudiness was obtained, showing the presence of less than 1 mgrm. of either SO_4 or PO_4. Upon adding 5 cc. dilute HCl the cloudiness disappeared, showing that this H_2O_2 contained no sulphates.

1. To separate solutions containing respectively 1, 2, and 3 mgrms. SO_3 as Na_2SO_3, 45 cc. HCl (1 : 2) and 5 cc. 2N.$BaCl_2$ were added. Any precipitate which formed was filtered off. To the filtrate 15 cc. 3 per cent H_2O_2 were added and the mixture evaporated to 25 cc. This insured the complete decomposition of the excess H_2O_2. A white precipitate was obtained in each case.

2. To separate solutions containing respectively 5, 10, 25, and 50 mgrms. C_2O_4, 45 cc. HCl (1 : 2), 5 cc. 2N.$BaCl_2$, *and 15 cc. 3 per cent* H_2O_2 *were added and the mixtures* evaporated to 25 cc. The solutions were made alkaline with NaOH, then acid with acetic acid. An excess of 10 cc. 36 per cent acetic and 10 cc. 2N.$CaCl_2$ were added. A white precipitate was obtained in each case.

3. It was suspected that H_2O_2 might destroy some tartrate. The following experiment was therefore made :—A solution containing 15 mgrms. $C_4H_4O_6$ was treated according to procedure given above in Experiment 1. After concentrating to 25 cc. the solution was made alkaline with NaOH and the test for tartrate completed as given in the scheme. A good positive test was obtained.

* Copyright, 1918, by Louis J. Curtman.

Conclusion.—It is possible to detect 1 mgrm. sulphite by oxidising it by means of H_2O_2 to sulphate and precipitating the latter with $BaCl_2$. Oxalates and tartrates are unaffected by H_2O_2. The hydrogen peroxide should be free of SO_4 and PO_4.

V.—*Detection of Sulphites and Thiosulphates when present Together.*

As pointed out in Note 7 under the scheme, the test for sulphites is not conclusive if thiosulphates have been shown to be present. A method for detecting sulphites and thiosulphates in the presence of each other is given by Autenrieth and Windaus (*Zeit. Ann. Chem.*, 1898, p. 295) based upon Table IV., which is also given by them.

TABLE IV.—*Solubilities in Water.*

Metal.	Sulphite.	Thiosulphate.
Ca	1 : 800	1 : 2
Sr	1 : 30,000	1 : 3·7
Ba	1 : 46,000	1 : 480

The procedure given in Note 7 was tested out by a number of test analyses, the results of which are given in Table V.

TABLE V.

No.	SO_3 (mgrms.).	S_2O_3 (mgrms.).	Result for SO_3.	Result for S_2O_3.
1.	1	500	Pos.	Pos.
2.	500	1	Pos.	Neg.
3.	500	5	Pos.	Pos.
4.	1	5	Pos.	Pos.
5.	0	500	Neg.	Pos.
6.	500	0	Pos.	Neg.
7.	1	0	Pos.	Neg.
8.	0	1	Neg.	Neg.
9.	0	5	Neg.	Pos.

Conclusion.—The above results show that the method is sensitive to 1 mgrm. SO_3 and 5 mgrms. S_2O_3 respectively.

VI.—*Detection of Tartrates.*

(*a*) *Cream of Tartar Test.*—Since no record of any work could be found in the literature concerning the sensitiveness of the cream of tartar test for tartrates, it was thought worth while to make a few tests to determine its sensitiveness. To separate solutions containing known amounts of $C_4H_4O_6$ as $K_2C_4H_4O_6$ 10 cc. of a saturated solution of $KC_2H_3O_2$ were added. The solutions were acidified with acetic acid. The total volume was 15 cc. The results are given in Table VI.

TABLE VI.

No.	$C_4H_4O_6$ (mgrms.).	Result after fifteen minutes.
1.	100	Clear.
2.	200	Clear.
3.	300	Clear.
4.	400	Cloudy.
5.	500	Heavy precipitate.

It is evident from the above results that this test cannot be used as it is not sensitive enough.

(*b*) *Test Based on the Formation of a Copper-tartrate Complex.*—This test has recently been investigated by Curtman and Harris (*Journ. Am. Chem. Soc.*, xxxix., 2623). Since the procedure recommended by these authors is only qualitative, it was the purpose of the following experiments to devise a method which would not only be sensitive but would at the same time afford a quantitative estimate of the amount of tartrate present.

1. Separate solutions containing increasing amounts of tartrates were made alkaline with NaOH, 2·5 cc. 25 per cent NaOH, and 3 cc. 2N$CuSO_4$ were added, making a total volume of 15 cc. The solutions contained in test-tubes were vigorously shaken for one minute, and im-

mediately filtered through filters prepared beforehand. To the clear filtrates 2 cc. concentrated NH_4OH were added. Negative results were obtained with amounts of tartrate as high as 5 mgrms.

2. The above procedure was modified by decreasing the amount of $CuSO_4$ from 3 cc. to 1·5 cc. The results obtained by this procedure showed that with 1 mgrm. $C_4H_4O_6$ a faint blue coloration was obtained, while 3—5 mgrms. gave decidedly positive tests. The following experiments were made to ascertain to what extent borates, phosphates, arsenites, and ammonium salts interfered with the modified procedure, since these substances were reported in the previously mentioned paper as giving the same tests.

Influence of Borates.—The procedure given above in 2 was applied to solutions containing known amounts of BO_3 and $C_4H_4O_6$ with the following results (Table VII.):—

Table VII.

No.	BO_3. Mgrms.	$C_4H_4O_6$. Mgrms.	Results.
1—10	50—250	0	Colourless.
11—14	250	1 - 5	Colourless.
15—16	250	10	Faint blue coloration (showed less than 5 mgrms.).
17—18	250	15	Light blue coloration (showed 5—10 mgrms.).
19—24	0	5—15	Decided blue coloration.

Influence of Phosphates.—The same procedure was applied to solutions containing known amounts of PO_4 and $C_4H_4O_6$ with the following results (Table VIII.):—

Table VIII.

No.	PO_4. Mgrms.	$C_4H_4O_6$. Mgrms.	Results.
1—10	50—200	0	Colourless.
11—14	250	1—5	Colourless.
15—16	250	10	Very faint blue coloration (1—2 mgrm.).
17—18	250	15	Faint blue coloration(<5 mg.).
19—20	250	20	Light blue coloration(5 mgrms.).
21—26	0	5—15	Decidedly blue coloration.

The experiments on phosphates were repeated with $Na_2HPO_4\ 12H_2O$ of three different manufacturers and with 85 per cent H_3PO_4, and the same results were obtained.

Table IX.—*Influence of Borates and Phosphates when present Together.*

No.	BO_3. Mgrms.	PO_4. Mgrms.	$C_4H_4O_6$. Mgrms.	Results.
1—6	250	250	0·0—10	Neg.
7—8	250	250	15	Pos. (<5 mgrms.).
9—10	0	0	5	Pos.

Table X.—*Influence of Chromates.*

No.	CrO_4 (mgrms.).	$C_4H_4O_6$ (mgrms.).	Result.
1—2	500	15	Greenish yellow.
3—4	500	0	Yellow.
5	0	15	Blue.

It was thought that the blue colour could be better seen if the chromate were removed. Experiments were made removing the CrO_4 by $BaCl_2$ before testing for tartrates as well as after completing the test. In both cases negative results were obtained, showing that it is better to test for tartrates in the presence of chromates. The difference in colour is easily seen when compared with a tube containing a solution of K_2CrO_4.

Action of Arsenites and Ammonium Salts.—Experiments made by the above procedure with 100 mgrms. AsO_3 as Na_3AsO_3 and 100 mgrms. NH_4 as NH_4Cl showed that arsenites and ammonium salts respond to the test in the same manner as do tartrates. The following procedure was devised for preventing the interference of arsenites and ammonium salts. The solution to be tested was made distinctly alkaline with NaOH, and 10 cc. 25 per cent NaOH was added in excess together with 20 cc. 3 per cent H_2O_2. The mixture was then evaporated nearly to dryness, water (20 cc.) was added, and the solution again evaporated nearly to dryness. Ten cc. of water were then added and the mixture filtered if necessary. The solution was transferred to a test-tube and the procedure applied. The results of a series of experiments are recorded in Table XI.

Table XI.

No.	NH_4. Mgrms.	AsO_3. Mgrms.	$C_4H_4O_6$. Mgrms.	Results.
1	500	0	0	Neg.
2	0	500	0	Neg.
3 - 4	250	250	0	Neg.
5	500	0	15	Pos.
6	0	500	15	Pos.
7—8	250	250	15	Pos.

Conclusion.—(*a*) Borates and phosphates when present in considerable amounts interfere with the formation of the copper-tartrate complex to the extent that no less than 15 mgrms. $C_4H_4O_6$ can be detected in their presence. (*b*) Chromates do not interfere with the test, since the difference in colour can easily be distinguished if a blank test is made at the same time. (*c*) Ammonium salts and arsenites interfere by giving the same test. In the proposed procedure the arsenite is oxidised to arsenate, which does not interfere with the test. The ammonium salts are decomposed by the addition of NaOH and the NH_3 completely expelled by the repeated evaporation of the solution to nearly dryness.

VII.—*To Determine to what Extent Sulphites, Thiosulphates, and Arsenites Respectively can Exist together with Chromates in Solution.*

1. A solution containing 250 mgrms. CrO_4 as K_2CrO_4 was mixed with a solution of 250 mgrms. SO_3 as Na_2SO_3 in a total volume of 25 cc. After standing for five minutes the solution acquired a greenish yellow colour, showing that even in neutral solution chromates are reduced by sulphites.

2. Experiment 1 was repeated, except that after mixing the solution was made slightly acid with dilute HCl. The solution immediately turned green, showing that the chromate is reduced immediately by the sulphite in acid solution.

3. Experiment 1 was repeated, except that after mixing the solution was made distinctly alkaline with an excess of Na_2CO_3(3N) solution and boiled for five minutes. The solution remained yellow, showing that in alkaline solution the chromate is not reduced by the sulphite. The last experiment was repeated with 1000 mgrms. SO_3 as Na_2SO_3 and 250 mgrms. CrO_4 as K_2CrO_4. The solution remained yellow as before.

4. A similar series of experiments were performed, replacing the sulphite by thiosulphate. The same results were obtained, except that a yellow precipitate of sulphur was obtained in each case in which the solution was made acid. Experiments with as little as 50 mgrms. SO_3 as Na_2SO_3 and 50 mgrms. S_2O_3 as $Na_2S_2O_3$ showed them to be incompatible with CrO_4 in either neutral or acid solution.

5. Two solutions, each containing 50 mgrms. AsO_3 as $NaAsO_2$ and 250 mgrms. CrO_4 as K_2CrO_4, were diluted to 25 cc. The first was allowed to stand ten minutes. The solution remained yellow. It was then heated to boiling, but no change occurred. The second solution was made acid with 5 cc. dilute HCl. The yellow colour immediately

TABLE XIV.

No.	SO_4.	SO_3.	C_2O_4.	F.	BO_3.	$C_4H_4O_6$	AsO_3.	AsO_4.	PO_4.	CrO_4.	CO_3.	S_2O_3.
1	25(1)	25	50	50	100	100	50	50	50			
2			100	100	100	100			100			
3	50	50	50	50	50	50	50	50	50			
4		50	100		200		50		100			
5	50		100	100		200		50				
6	25	25	100	100			100	50	100			
7	100				150	150	100					
8					150	100	100		150			
9	25	100		25	150			100	100			
10	100	5	25	50	25	250		25	25			
11	50	50	50	100	100		50	50	50			
12	50	50	50		50	100	50	50	50			
13	50		50	100	50	100	50	50	50			
14	100	50	50	50	50	100	50		50			
15	50	50	50		50	100	50	50				
16	5		25	50	25	200		25	100	50		
17				25	200	50			25	100	50	
18	25	25	25	50	50	50		50	50		50	100
19			100		150						100	150
20				100		200		100	100	25		

(1) The figures in this Table represent mgrm. quantities of the acid radicals.

All gave satisfactory results. In Analyses 3, 10, 12, 13, 14, 15, 16, and 18, BO_3 was found by testing the original solution and not during the procedure, since they were present in amounts which are not precipitated at the beginning. In Analyses 3, 17, and 18, $C_4H_4O_6$ was found by testing the original solution for the same reason.

changed to green, showing that as little as 50 mgrms. AsO_3 are incompatible with 250 mgrms. CrO_4 in acid solution.

VIII.—*Detection of Carbonates.*

(See diagram and description of apparatus for carbonates under Note 1 following the scheme).

(*a*) *In the Absence of Sulphite.*—Anhydrous $CaCO_3$ was mixed with pure SiO_2 and separate portions of the mixture containing increasing amounts of CO_3 were treated by the procedure given in Note 1 following the scheme. Five cc. of dilute HCl was used without the addition of the H_2O_2. he results are given in Table XII.

TABLE XII.

No	CO_2 (mgrms.).	Results (appearance of $Ba(OH)_2$).
1—4	0	Clear.
5—8	1—2	Cloudy.
9—10	5—10	White precipitate.

(*b*) *In the Presence of Sulphites.*—500 mgrms. SO_3 as Na_2SO_3, the anhydrous product of three different manufacturers, were respectively treated by the procedure given in Note 1 following the scheme. All gave precipitates with $Ba(OH)_2$ solution. The sulphites were suspected to contain carbonates as impurities. To ascertain whether or not these precipitates were due to incomplete oxidation of SO_3 to $SO_4(BaSO_3)$, or to carbonate present in the Na_2SO_3, 5 cc. dilute H_2SO_4 and a few drops of 1 per cent $KMnO_4$ were added to each of the precipitates. The failure of the mixtures to bleach the potassium permanganate showed that all three sulphites contained carbonates. Finally, Merck's reagent grade crystallised sodium sulphite ($Na_2SO_3 \cdot 7H_2O$) was tried, and was found free of carbonate. The anhydrous sulphites were found to contain about 80 per cent Na_2SO_3, while the crystallised sulphite contained 67 per cent Na_2SO_3. Separate portions of a mixture of $CaCO_3$ and SiO_2 containing increasing amounts of CO_3 and 500 grms. SO_3 as $Na_2SO_3 \cdot 7H_2O$ were treated by the same procedure with the results given in Table XIII.

TABLE XIII.

No.	SO_3 (mgrms.).	CO_3 (mgrms.).	Result.
1—4	500	0	Clear.
5—6	500	1	Cloudy.
7—10	500	5—10	White precipitate.

Conclusion.—The test given in the scheme for carbonates is sensitive to 1 mgrm. of carbonate either alone or in the presence of 500 mgrms. SO_3.

IX.—*Influence of Ammonium Salts on the Precipitation of Borates and Tartrates as Calcium Salts.*

1. To a solution containing 500 mgrms. $C_4H_4O_6$ as $NaKC_4H_4O_6$ 3 grms. NH_4Cl were added, and the solution made alkaline with NH_4OH. Ten cc. $CaCl_2$ were then added in a total volume of 50 cc. A white precipitate began to form after standing five minutes.

2. The above experiment was repeated using 5 grms. NH_4Cl. A cloudiness began to appear after standing ten minutes.

3. Experiment 2 was repeated using a volume of 100 cc. No precipitate was obtained at the end of ten minutes.

4. A solution containing 500 mgrms. BO_3 as $Na_2B_4O_7$ and 5 grms. NH_4Cl was made alkaline with NH_4OH and 10 cc. 2N.$CaCl_2$ added in a total volume of 100 cc. No precipitate formed upon standing ten minutes.

Conclusion.—Five grms. NH_4Cl in a volume of 100 cc. will keep in solution 500 mgrms. $C_4H_4O_6$ and 500 mgrms. BO_3 as calcium salts.

Test Analyses.

To test the method, test analyses were made as given in Table XIV.

Summary.

1. A scheme is proposed by means of which the acids of Group I. may be systematically detected and the relative amounts approximately estimated. The chief features of the method are:—

(*a*) The preliminary precipitation of all of the acids of Group I. with a mixture of $BaCl_2$ and $CaCl_2$.

(*b*). The treatment of the precipitate with HCl to dissolve all but SO_4.

(*c*) The oxidation by means of H_2O_2 of the sulphite to sulphate and the precipitation of the latter with $BaCl_2$.

(*d*) Removal of Ba with $(NH_4)_2SO_4$.

(*e*) Separation of F, AsO_4, and PO_4 from BO_3 and $C_4H_4O_6$ in alkaline solution in the presence of sufficient ammonium salts.

(*f*) Separation of C_2O_4 and F from AsO_4 and PO_4 in an acetic acid solution containing an excess of Ca ions.

(*g*) Reduction of AsO_4 to AsO_3 with H_2SO_3 and separation from PO_4 by H_2S in HCl solution.

(*h*) Separate tests for carbonates and chromates.

(*i*) Separate test for the determination of the state of oxidation of arsenic.

2. The results of a number of test analyses show the method to be trustworthy.

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THE PREPARATION AND HYDROLYSIS OF ESTERS DERIVED FROM THE SUBSTITUTED ALIPHATIC ALCOHOLS.

By GEORGE R. BANCROFT.

IN a recent paper (*Am. Journ. Sci.*, 1917, xliv., 371) published from this laboratory an account has been given of the preparation of esters derived from the α and β substituted ethyl alcohols and of an investigation of the effect of their constitution upon the rate of hydrolysis. It was shown by a study of α-chloroethyl acetate, α-chloroethyl propionate, and α-ethoxyethyl acetate that the substitution of halogen or an alkoxyl group in the α-position of the alkyl radical of an ester accelerates the decomposition of the ester to such an extent that the reaction velocity cannot be measured. In the case of all three esters of this type that were hydrolysed acetaldehyde formed one of the hydrolysis products. It was further observed that the substitution of hydroxyl, methoxyl, ethoxyl, chlorine, and bromine, in the β-position of the ethyl radical of ethyl acetate, produces a considerable retardation of the rate of hydrolysis. The hydroxyl and ethoxyl groups, and chlorine, produced practically the same degree of retardation; methoxyl and bromine a somewhat smaller retardation. In preparing the esters necessary for this study it was found that the β-hydroxyethyl acetate may be obtained by refluxing equimolecular quantities of ethylene glycol and glacial acetic acid for eight hours over twice the theoretical quantity of anhydrous copper sulphate; and that β-ethoxyethyl alcohol is formed by digesting equimolecular quantities of β-bromoethyl acetate and sodium ethylate for half an hour in alcoholic solution.

In the present article this investigation has been extended to the study of esters derived from halogen substituted propyl alcohols, and the results are here given to show the effect of this substitution in the alkyl portion of the esters upon the rate of hydrolysis.

The following esters were prepared and hydrolysed:—

Unsymmetrical β-monochloroisopropyl acetate,—

$$\begin{matrix} CH_3\diagdown \\ \qquad\qquad CH.O.CO.CH_3. \\ CH_2Cl\diagup \end{matrix}$$

Symmetrical β,β′-dichloroisopropyl acetate,—

$$\begin{matrix} CH_2Cl\diagdown \\ \qquad\qquad CH.O.CO.CH_3. \\ CH_2Cl\diagup \end{matrix}$$

Unsymmetrical β,γ-dichloropropyl acetate,—

$$CH_2Cl.CHCl.CH_2O.CO.CH_3.$$

Unsymmetrical β,γ-dibromopropyl acetate,—

$$CH_2Br.CHBr.CH_2O.CO.CH_3.$$

Preparation of Materials.

Symmetrical β,β′-dichloroisopropyl acetate was prepared by treating the β,β′-dichlorohydrin of glycerol, which was in stock, with acetyl chloride in slight excess of the theoretical amount by the method of Henry (*Ber.*, 1871, iv., 704; *Bull. Sci. Acad. Roy. Belg.*, 1906, xlii., 261; *Rec. Trav. Chim.*, 1907, xxvi., 89). The pure ester boiling at 201—203° was obtained by fractionation. The halogen content of the ester was also determined as a further test of the purity of the substance.

Chlorine found—I. 41·45 per cent; II. 41·92 per cent.
Chlorine calculated—41·47 per cent.

Unsymmetrical β,γ-dichloropropyl acetate was prepared by combining equimolecular quantities of the chlorohydrin and acetyl chloride according to R. de la Acena (*Comptes Rendus*, 1904, cxxxix., 668). The ester purified by fractional distillation, boiled at 197—198°. The halogen content was found by analysis.

Chlorine found—I. 40·33 per cent; II. 40·59 per cent.
Chlorine calculated—41·47 per cent.

β,γ-dichloropropyl alcohol used in the preparation of this ester was obtained by passing dry chlorine gas into allyl alcohol at 0° until the theoretical quantity of chlorine gas had been absorbed.

This method of preparation is discussed in the literature by Tollens (*Ann.*, 1870, clvi., 164), Hübner and Müller (*Ann.*, 1871, clix., 179), Munder and Tollens (*Zeit. Angew. Chem.*, 1871, xiv., 252). The chlorohydrin was separated by fractionation, boiling at 182—183°. The yield from one hundred grms. of allyl alcohol varied from eighteen to twenty-two grms. The allyl alcohol used was prepared by the method of Koehler (*Bull. Soc. Chim.*, 1913 [4], xiii., 1103).

Unsymmetrical β,γ-dibromopropyl acetate was obtained by treating the β,γ-dibromohydrin, which was in stock, with acetyl chloride in slight excess. The ester purified

by fractionation, boiled at 227—228°. Aschan (*Ber.*, 1890, xxiii., 1827) prepared this ester by treating the dibromohydrin with acetic anhydride.

β-monochloroisopropyl alcohol was prepared from allyl chloride by the method of Oppenheim (*Ann. Spl.*, 1868, vi., 367; *Rec. Trav. Chim.*, 1902, xxi., 535). Two mols. of concentrated sulphuric acid were gradually added to one mol. of allyl chloride at 0°, when a thick reddish brown oily substance was formed, which became dark brown in colour upon standing. The reaction seemed to be additive in character, and may be represented by the following equation:—

$$\begin{matrix} CH_2 & & CH_3 \\ | & & | \\ CH & + H_2SO_4 \rightarrow & CH.SO_4H \\ | & & | \\ CH_2Cl & & CH_2Cl \end{matrix}$$

The flask containing the reaction mixture was imbedded in snow and water, and after each addition of acid was shaken vigorously. The mixture was not permitted to warm up, because when the temperature was allowed to rise clouds of hydrochloric acid gas were evolved and charring took place, indicating decomposition. After standing twenty-four hours, the dark-coloured chloroisopropyl acid sulphate was diluted with eight to ten times its volume of water, and heated in a flask fitted with a reflux condenser on a water-bath from one to two hours. The hydrolysis may be represented by the equation—

$$\begin{matrix} CH_3 & & CH_3 \\ | & & | \\ CH.SO_4H + H - O - H & \rightarrow & CH.OH + H_2SO_4 \\ | & & | \\ CH_2Cl & & CH_2Cl \end{matrix}$$

The solution of the hydrolysis products was then distilled, and the distillate collected until a temperature of 128—130° was reached, when the distillation ceased and sulphur dioxide was evolved. The distillate was then neutralised with potassium carbonate, and the oily liquid separating was extracted with ether, salting out with sodium chloride. The ether extract was then dried over freshly fused potassium carbonate. The ether was distilled off, the residue passing over at 120—130°, which, when redistilled, boiled definitely at 126—127, as described by Henry (*Rec. Trav. Chim.*, 1903, xxii., 209).

In the account of this work done by Oppenheim (*Ann. Spl.*, 1868, vi., 367), the details of the preparation of the chloroisopropyl acid sulphate are not given. After carrying out the distillation of the solution containing the products of hydrolysis, Oppenheim separated the β-monochloroisopropyl alcohol from the distillate by saturating it with potassium carbonate. Much better results were obtained by the author by neutralising the solution with potassium carbonate at this point and extracting with ether as described above.

The β-monochloroisopropyl acetate was prepared by causing equimolecular quantities of β-monochloroisopropyl alcohol and acetyl chloride to react. The resulting ester was purified by fractionation, boiling at 149—150°, the same temperature reported by Henry (*loc. cit.*).

The allyl chloride used in the preparation of the unsymmetrical β-monochloroisopropyl alcohol was prepared by the method of Tollens (*Ann.*, 1870, clvi., 154), by treating three mols. of allyl alcohol with one mol. of phosphorus trichloride. The allyl alcohol was placed in a distilling flask connected with a Liebig's condenser, and the phosphorus trichloride was added through a dropping funnel, the flask being cooled with ice-water and shaken vigorously from time to time as the addition was carried on. The reaction may be represented by the following equation—

$$3CH_2{=}CH.CH_2OH + PCl_3 \rightarrow CH_2{=}CH.CH_2CL + H_3PO_3.$$

When all the phosphorus trichloride had been added the temperature of the water-bath was maintained at 40° until all the hydrochloric acid was evolved, then raised sufficiently to distil off the fraction of allyl chloride boiling at 45—50°. During the distillation the flask was shaken vigorously at intervals to assist in volatilising the allyl chloride and separating it from the thick and heavy phosphorous acid.

In performing this fractionation it was found that if the temperature were permitted to rise to the vicinity of the boiling-point of allyl alcohol, an explosion occurred wrecking the apparatus and setting free red phosphorus, which was distributed through the distillation apparatus, while at the same time a strong garlic odour of phosphine or hydrogen phosphide was formed. De Mole (*Rec. Trav. Chim.*, 1876, ix., 48) and Béchamp (*Comptes Rendus*, 1856, xlii., 227) record the same difficulty in carrying on similar work.

When the distillation was completed the distillate was washed with water; the allyl chloride forming a layer on the surface of the water solution was removed by a separatory funnel, dried over calcium chloride, and redistilled, boiling at 46—47°.

Meeting with the above-mentioned difficulty in the method of procedure just described, another treatment was adopted with satisfactory results. The procedure in this case was based upon the fact that allyl chloride is insoluble in water, while phosphorous acid is soluble. The allyl alcohol was placed in a flask fitted with a reflux condenser and the phosphorus trichloride was added by means of a dropping funnel supported by a grooved cork in the upper end of the condenser. The flask was held in a water-bath filled with ice-water, and shaken at intervals during the addition of the chloride of phosphorus. When the addition was complete the reaction mixture was refluxed for an hour, permitted to cool, and washed with a sufficient quantity of water to remove the phosphorous acid. The allyl chloride was then separated, dried, and redistilled as already described in the former procedure.

The latter method of treatment seemed to be very satisfactory, and the yield of this method showed a slight increase over that of the first, due to the fact that a small amount of the allyl chloride was held back from distillation by the phosphorous acid. This was shown by dissolving up the phosphorous acid left as a residue after the distillation in the first process. The yield obtained by treating allyl alcohol with the phosphorous trichloride varied from 39·4 per cent to 37·8 per cent of the theoretical.

Hydrolysis of Esters.

Esters Derived from Halogen Substituted Propyl Alcohols—These esters were hydrolysed in decinormal hydrochloric acid by the methods already outlined (*Am. Journ. Sci.*, 1917, xliv., 371) in connection with the hydrolysis of ester derived from the β-substituted ethyl alcohols. Hydrolysis measurements were made of the β,β'-dichloropropyl acetate and the β,γ-dichloropropyl acetate at 25°, 35°, and 45°, and of the β-monochloroisopropyl acetate at 35° and 45°, and constants were calculated for these esters as may be seen in Table I., and these results are further sumarised in Table II.

The dichloro-substituted propyl acetates were found to be soluble in water only to the extent of about four cubic centimetres per litre. The β,γ-dibromopropyl acetate was much less soluble, making it impossible to dissolve enough of this ester in decinormal hydrochloric acid to make satisfactory velocity measurements. The β-monochloroisopropyl acetate proved to be more soluble than the dichloro-substituted propyl acetates, eight cubic centimetres of this ester dissolving in one litre of water.

In the case of the dichloro-substituted propyl acetates one cubic centimetre of each ester was dissolved in 250 cc. of decinormal hydrochloric acid previously warmed in the thermostat to the required temperature. The flask was then vigorously shaken, and as soon as the ester was completely dissolved 25 cc. of the reaction

TABLE I.—*Hydrolysis of Chloro-substituted Propyl Acetates in Decinormal Hydrochloric Acid.*

Temperature.	35°.	45°.	25°.	35°.	45°.	25°.	35°.	45°.
Time in minutes	1325	438	2877	630	216	3146	630	210
$k \times 10^5$	75·5	(158)	26·4	(36·6)	(78)	(29·7)	(67·4)	(165)
	74·4	182	25·2	65·3	165·0	27·5	83·3	202
	75·4	184	26·6	67·7	166·0	27·8	84·9	201
	74·8	184	27·6	66 6	165·0	27·9	83·1	200
	75·5	188	26·3	67·7	165·0	28·5	83·1	203
	75·0	185	26·6	65·7	167·0	27·9	83·0	206
	75·6	186	26·0	67·1	166·0	—	—	—
Averages	75·2	185	26·4	66·7	166·0	27·9	83·4	202
Average (duplicate)	75·5	186	26·8	66·8	165·0	27·8	83·2	203

mixture was withdrawn and titrated with decinormal sodium hydroxide, using phenolphthalein as an indicator. Further titrations were made from time to time as already described (*Am. Journ. Sci.*, 1917 [4], xliv., 371) in the preceding series of esters hydrolysed, from which constants were determined. By making occasional titrations with decinormal silver nitrate it was shown that there was no splitting out of halogen at 25°, 35°, and 45°.

TABLE II.—*Summary.*

Temperature.	$k \times 10^4$. 25°.	35°.	45°.	Temperature coefficients. 25—35°.	35—45°.
Ethyl acetate	64·7	162·1	379	2·5	2·3
	64·8	161·9	376		
β-Chloroethyl acetate ..	46·5	117 6	275	2·5	2·3
	47·2	117·6	275		
β-Bromoethyl acetate..	55·1	134·5	298	2·4	2·2
	56·5	134·8	298		
Propyl acetate..	67·1	167·8	386	2·5	2·3
	66·8	167·0	384		
β-Chloroisopropyl acetate	—	75·2	185	—	2·4
	—	75·5	186		
Symmetrical β, β′-dichloroisopropyl acetate	26·4	66·7	166	2·5	2·5
	26·8	66·8	165		
Unsymmetrical β,γ-dichloropropyl acetate ..	27·9	83·4	202	2·9	2·4
	27·8	83·2	203		

Two cubic centimetres of the β-monochloroisopropyl acetate were dissolved in 250 cc of decinormal hydrochloric acid, and hydrolysis measurements were made as in case of the other esters. On titrating the portions of the reaction mixture withdrawn at the intervals recorded in Table I., with decinormal sodium hydroxide and then with silver nitrate, it was found that no halogen was liberated in the titration made at 35°. At 45° in the final titration there was a small amount of halogen acid set free, for which correction was made in calculating the constants.

The velocity constants recorded in Table I. were calculated by using the titration formula for monomolecular reactions—

$$k = 2{\cdot}3/t\ [\log (T_\infty - T_0) - \log (T_\infty - T_n)\ ]$$

where T_0 is the initial titration, T_∞ the final titration, and T_n an intermediate titration all expressed in cubic centimetres of decinormal sodium hydroxide, and t represents the time interval in minutes between the initial titration T_0 and that represented by T_n.

Discussion.

In this work, as has been found in previous experience, the substitution of halogen in the β-position of the alkyl radical of the ester produces a marked retardation on the rate of hydrolysis. This retardation is further increased by the substitution of two chlorine atoms in the β,γ-position, and becomes still greater when thechlorine atoms occupy the β,β′-position. The degree of the effect of these substitutions upon the rate of hydrolysis can be readily seen on consulting Table II.

On making a comparison of the respective rates of hydrolysis of β-chloroethyl acetate and β-chloroisopropyl acetate with those of their corresponding unsubstituted esters it is seen that the retardation in the case of the β-chloroisopropyl acetate is much greater. This may be attributed to the iso-character of this ester. It is also to be observed that the more effective retarding influences of the dichloro-substitution in the β,β′-position may be due to the iso-structure of the ester in this case. E. W. Dean (*Am. Journ. Sci.*, 1914 [4], xxxvii., 331) in his study of the effect of the substitution of the acyl radical of an ester upon the rate of hydrolysis found that substituted and unsubstituted isobutyrates decompose more slowly than the corresponding normal esters. This investigation seems to furnish further evidence of the retarding influence of the iso-structure upon the rate of hydrolysis of the ester.

The retarding effect produced by the substitution of halogen in the β-position of the alkyl radical forms a striking contrast to the accelerating influence produced by substitution in the α-position, where the decomposition of the ester is promoted to such an extent that the rate of hydrolysis is not measurable. As a result of this study it is seen that the position of the halogen with respect to the carboxyl group has an important influence upon the hydrolysis. On making a comparison of the results found in this investigation with those obtained by Drushel (*Idem.*, 1912 [4], xxxiv., 69), in studying halogen substitution of the acyl radical of an ester, it is interesting to note that substitution in the α-position of either the alkyl or the acyl radical of an ester produces a decided acceleration of the rate of hydrolysis, but that this acceleration is much greater in the case of the alkyl substitution.

The temperature coefficients for an increase of ten degrees show very little variation. An exception is found in the case of the β,γ-dichloropropyl acetate between 25° and 35°, where the coefficient seems to be 2·9 (see Table II.).

Summary.

1. A convenient method of procedure is introduced for the treatment of allyl alcohol with phosphorus trichloride in the preparation of allyl chloride based upon the insolubility of allyl chloride and the solubility of the phosphorous acid produced in the process.

2. In preparing β-monochloroisopropyl alcohol, Oppenheim brought about the separation of this alcohol by saturating the distillate obtained from the solution of hydrolysis products with potassium carbonate. It was found in performing this operation that a more convenient and complete separation was effected by salting out the alcohol with sodium chloride and extracting with ether.

3. Substitution of chlorine in the β-position of the alkyl radical of the ester produces a marked retardation of the rate of hydrolysis. Substitution of two chlorine atoms in the β,γ-position produces a greater and in the β,β′-position a still greater retardation.

4. Evidence is furnished to show that the iso-structure in the molecule of an ester produces a retarding influence on the rate of hydrolysis.

The writer is indebted to Prof. W. A. Drushel for his co-operation in this work.—*Journal of the American Chemical Society*, xli., No. 3, March, 1919.

CHEMICAL ACTION PRODUCED BY RADIUM EMANATION. I.*

The Combination of Hydrogen and Oxygen.

By S C. LIND.

(Continued from p. 34).

5. *Influence of the Size of the Reaction Bulb.* (*Law of the Inverse Square of the Diameter*).

Increasing the size of the reaction bulb influences the velocity constant of the chemical reaction in two oppositely directed ways:—First, with the pressure remaining constant, the effective path of the α-particle is lengthened directly by 0·7 of the radius of the spherical bulb (S. C. Lind, *loc. cit.*), and hence, other things being equal, the velocity is directly proportional to the diameter of the bulb, provided that the diameter does not exceed the range of any of the α-particles. Second, a given amount of chemical action or volume change will produce a change of pressure dependent on the volume of the reaction bulb. The smaller the bulb the larger the change of pressure produced, in proportion to the cube of the diameter. Combination of these two opposite effects shows that the velocity constant expressed with reference to pressure, as in Equation 1, must vary inversely with the square of the diameter of the reaction bulb. This data from Table I. are summarised in Table II. so as to show that this is actually the case to a high degree of precision for bulbs varying in diameter from 1 to 5·5 cm. and in volume over almost 200-fold.

Table II.—*Effect on the Velocity Constant* ($k\mu/\lambda$) *of varying the Volume of Reaction Bulb.*

Approx. diam. of sphere. Cc.	True diam. D. Cm.	Vol. of sphere. Cc.	$k\mu/\lambda$ (constant found).	$(k\mu/\lambda)/D^2$.
1	0·9647	0·4701	(89·6) (*a*)	83·4
2	1·925	3·738	23·04	85·3
2⅜ (cylinder) (*b*)	2·375	6·787	14·76	83·3
3	2·924	13·272	9·92	84·8
4	3·963	32·58	5·30	83·2
5	4·893	61·32	3·52	84·3
5½	5·613	92·60	2·68	84·1
			Average	84·1

(*a*) Extrapolated value. See following paper on "Recoil Atoms."

(*b*) Vessel cylindrical for sake of comparison with spherical ones).

This appears to establish thoroughly the nature of the law governing the influence of the size of the sphere on the velocity of the reaction. There appear to be no reasons why it should not apply to any other gaseous reaction as well as to the one under consideration. It appears to the writer to confirm his earlier theory of the average path of α-particles in spherical volumes with reference to their chemical effect.

On passing to volumes other than spherical it has not been possible as yet to give a mathematical treatment of the average path. A graphical treatment for cylinders, such as will be represented by glass tubes of moderate dimensions, showed that the average path would have the same numerical value as in a sphere of the same volume. In the present work it was not only possible to test this conclusion experimentally, but it was also of great service in comparing the present results with those of Cameron and Ramsay, who used for this reaction glass tubes instead of spherical bulbs. Accordingly, one spherical reaction chamber was used, 1·8 cm. in diameter, 4 cm. long, having an actual volume of 6·787 cc., equal to the volume of a sphere 2·375 cm. in diameter. In Table II. the data for this cylindrical vessel have been reported together with the spheres, and it is found that the cylindrical volume furnishes a value of 83·3 for $(k\mu/\lambda)/D^2$, agreeing with the other values for true spheres. This is of considerable interest in that it enables a direct comparison between most of Cameron and Ramsay's results and the present ones. (See Section 9 for a later discussion).

It may be of interest to inquire how great the diameter of the reaction bulb may become before the validity of the formula $(k\mu/\lambda) = (84{\cdot}1/D^2)$ is affected. Evidently it still holds for the largest bulbs used in these experiments, and, as will be seen in Section 9, it still holds within 2 per cent for Scheuer's results in a bulb of 7·18 cm. diameter at a pressure of 1580 mm. Even on considering that the stopping power of the electrolytic mixture is only about one-half that of air, and that the average path is about 0·7 of the radius, it is evident that many α-particles are being completely absorbed before reaching the wall, while many others reach the end of their range where the ionisation is no longer proportional to the path travelled. These two effects tend to compensate each other, but when the diameter of Scheuer's bulb reaches 8·94 cm. at a pressure of 1680 mm. the value of $k\mu/\lambda$ drops 6·7 per cent below the theory for uniform path, and continues to fall for larger sizes. The limit of the applicability of the formula appears to be at about 7 cm. for 1580 mm. of $2H_2—O_2$, which would be a diameter of 10 cm. at 760 mm., corresponding to an average path in air of about 3·7 cm.

It was the writer's earlier view (*loc. cit.*) that the general law would hold only over the first 2 or 3 cm. of path of the α-particle where ionisation remains constant. This would doubtless be true for a single type of α-particle; for example, from Ra C alone, but comparison of Bragg's combined ionisation curves indicates that ionisation per length of path in emanation in equilibrium would remain almost constant up to 4 cm. of air, agreeing very well with the results of the foregoing paragraph ("Studies in Radio-activity," 1912, p. 21; *Phil. Mag.*, 1905, [VI.), x., 323).

6. *Influence of Changing the Proportions of Hydrogen and Oxygen.*

All reactions discussed in the foregoing sections have been carried out using electrolytic hydrogen and oxygen in exact proportions of 2 to 1 by volume. The effect of an excess of either gas can be predicted on the assumption that the change thus produced in the specific ionisation of the gas mixture will change the reaction velocity correspondingly. The specific (molecular) ionisation compared with air is, according to Bragg, 1·09 for oxygen and 0·24 for hydrogen ("Studies in Radio-activity," Macmillan, 1912, p. 65). Consequently, an initial excess of oxygen should increase the relative reaction velocity. The velocity constant calculated by Equation 1 should be initially higher than the normal, and should continue to rise as the mixture became relatively richer in oxygen with the progress of the reaction. With initial excess of hydrogen the case should be exactly the opposite; the velocity constant should start abnormally low and show a further fall as the mixture enriched in hydrogen.

Both cases have been experimentally investigated and the predictions found to be fully confirmed. Since the specific ionisation, however, is variable in these reactions Equation 1 is not strictly applicable. The development of a new equation taking into account the changing ionisation is so complicated that the simpler method has been adopted of using Equation 1 to show that the change

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in velocity is proportional to the change in specific ionisation. Since $k\mu/\lambda$ now becomes a variable it should be calculated over short intervals to avoid undue masking of its variability. To accomplish this the value of $k\mu/\lambda$ is calculated, not from the beginning in each case, but from each measurement to the next, a procedure quite common in chemical kinetics ("Mellor, "Chemical Statics and Dynamics," Longmans, Green, and Co., 1904, pp. 31, 36, 37).

In this form the equation may be written—

$$[(k\mu/\lambda)' = \log_e P_2/P_1)/(E_0(e^{-\lambda t_1} - e^{-\lambda t_2}) \quad . \quad . \quad 2.$$

Table III. gives the data for the initial mixture $4H_2—1O_2$, and in Col. 4 the application of Equation 2 shows that $(k\mu/\lambda)'$ is not constant, but falls approximately as required by the change of specific ionisation (*cf.* Col. 5). Col. 5 has been calculated from the normal value of $(k\mu/\lambda)$ for a bulb of this size and the changing specific ionisation.

TABLE III.—*Effect of Excess of* H_2 *on the Velocity Constant.*

Init. mixt. $4H_2—1O_2$. Vol. = 11·64 cc. Diam. = 2·812 cm. E_0 = 0·1169 curies.

Time. Days.	Time. Hours.	Total P. mm. Hg.	Partial P. O_2.	$(k\mu/\lambda)'$ (found).	$(k\mu/\lambda)'$ calc. from spec. ionisation.	$(k\mu/\lambda)'$ for Pr. O_2.
0	0	682·8	136 6	—	—	—
0	19·25	605·9	110·9	7·92	7·93	13·20
1	3·25	580·3	102·4	7·30	7·50	13·50
1	23·00	528·2	85·0	7·17	7·38	14·20
2	23·67	480·6	69·2	6 80	7·17	14·90
4	19·33	425·2	50·7	6·42	6 89	16·30
6	3·75	397·9	41·6	6·24	6·62	18·61
7	19·67	375·8	34·2	5·74	6·46	19·50
8	23·75	363·9	30·2	5·89	6·30	22·71
11	19·33	346·7	24·5	5·24	6·10	22·71
13	22·33	338·4	21·8	5·50	5·97	27·91
15	22·50	332·9	19·9	5·65	5 90	30·24

(NOTE.—10·65 is the value of ku/λ for a normal mixture ($2H_2—1O_2$) in a bulb of this size).

Another question of importance can be considered in this connection, whether it is only one component or both, that are effectively activated by the α-particle; or, in terms of ionisation, are both the hydrogen and oxygen ions capable of taking part in the chemical reaction? In having shown the reaction to be proportional to the specific ionisation of the mixture this question has already been answered in favour of the supposition that both ions are active. But it may receive a more definite answer still by calculating $(k\mu/\lambda)'$ for partial pressures of the components. In the last column of Table IV. will be found values using partial pressure of oxygen. As will be seen the constant rises, which can be interpreted only as meaning that the partial pressure of oxygen alone does not control the reaction, since there is no interpretation to be put on a rising velocity constant.

In Table IV. will be found results for mixtures of oxygen in chemical excess of hydrogen in the proportions 1 to 1, 2 to 1, and 4 to 1.

The comparison with the theoretical values is not made, since the change in specific ionisation would not be so great as in the mixture $4H_2—1O_2$; but it can be seen that the constants show a tendency to rise in all cases and start abnormally high when compared with the electrolytic mixture as required by theory.

From the data for the 2 to 1 and 4 to 1 mixtures (Table IV.) can also be noticed that when the hydrogen is exhausted the reaction does not stop entirely, but the velocity drops at once to one of an entirely lower order. This is due to some reaction that the oxygen alone undergoes when acted on by α-rays, which is more fully discussed in Section 7.

TABLE IV.—*Effect of Excess of* O_2 *on the Velocity Constant.*

Orig. mixt. $1O_2—1H_2$. Vol. = 13·517 cc. Diam. = 2·955 cm. E_0 = 0·1401 curies.

Time. Days.	Time. Hours.	P mm. Hg.	Pt.P. H_2 mm. Hg.	$(k\mu/\lambda)'$ found.
0	0	510·4	255·2	(*a*)
0	16·00	422·0	196·3	12·0
0	23 75	386·8	172·8	12·4
1	23·75	300·7	115·4	13·0
2	17·17	254·8	84·8	13·9
3	20·00	203·9	50·8	14·2
4	20 00	172·3	29·8	14·6
5	20·00	150·1	15·0	14·3
6	16·00	130·6	2·0	20·4
7	0·42	127·6	0·0	9·1

Orig. mixt. $2O_2-1H_2$. Vol. = 13·849 cc. Diam. = 2·983 cm. E_0 = 0·1542 curies.

Time. Days.	Time. Hours.	P mm. Hg.	Pt.P. H_2 mm. Hg.	$(k\mu/\lambda)'$ found.
0	0	553·5	184·5	(*b*)
0	16·25	446 6	113·2	12·13
0	20·58	421·0	96·1	13·66
1	16·25	327·5	33·9	13·86
1	20·58	310·5	22·5	14·69
2	0·08	297·2	13·7	15·43
2	16·25	253·3	0	13·02
2	23·75	249·1	0	3·19
5	0·17	245·9	0	0·47
8	17 08	242·0	0	0·52

Orig. mixt. $4O_2—1H_2$. Vol. = 12·609 cc. Diam. = 2·887 cm. E_0 = 0·1093 curies.

Time. Days.	Time. Hours.	P mm. Hg.	Pt.P. H_2 mm. Hg.	$(k\mu/\lambda)'$ found.
0	0	660·3	132·1	(*c*)
0	6·16	611·6	99·7	15·46
0	11·58	573·5	74·2	15·47
0	21·92	509·4	31·5	16 68
1	2·00	487·2	16 7	16·33
1	6·42	464·7	1·7	15·54
1	22 67	451·8	0	2·87
4	21·83	448 6	0	0·22
12	5·58	444·1	0	0·31
18	22·00	443·3	0	0·26

(*a*) Normal constant $(k\mu/\lambda)$ for $2H_2—1O_2$ in bulb of 2 955 cm. diam. is $84·1/D^2$ = 9·63.

(*b*) Normal constant $(k\mu/\lambda)$ for $2H_2—1O_2$ in bulb of 2 983 cm. diam. is $84·1/D^2$ = 9·45.

(*c*) Normal constant $(k\mu/\lambda)$ for $2H_2—1O_2$ in bulb of 2·887 cm. diam. is $84·1/D^2$ = 10·09.

(To be continued).

BOARD OF TRADE ANNOUNCEMENT.

TRADE WITH GERMANY AND GERMAN-AUSTRIA.

IN view of the raising of the blockade, the Board of Trade have issued general licences under the Trading with the Enemy legislation authorising with certain reservations the resumption of trade with Germany and German-Austria.

The licences do not remove the existing restrictions upon the payment of debts and the return of property due or deliverable to persons in Germany and German-Austria in respect of pre-war transactions. Moreover, any permission which may be necessary in respect of any transactions under Defence of the Realm Regulation 41 D must be obtained from the Treasury.

The licences do not permit the importation from Germany or German-Austria of any goods included in the Prohibition of Import Proclamations and not covered by a general licence issued under those proclamations. Further, export licences must be obtained from the Export Licence Department, 1, Queen Anne's Gate, Westminster, S.W. 1, before goods included in Lists "A" and "B" of prohibited exports are shipped to those countries, but no licences are required in respect of goods included in List "C."

ON THE

PHOTOGRAPHIC SPECTRA OF METEORITES.*

By Sir WILLIAM CROOKES, O.M., F.R.S., LL.D., &c.

FOR several years I have been engaged on the spectrum analysis of Meteorities. Many meteoric specimens have come into my possession—through the kindness of friends—especially am I indebted to the Trustees of the Natural History Museum and to Dr. Prior, who presented me with specimens of such of the meteorities of which the quantity in their possession would not be appreciably diminished by the loss of the two or three grms. required for my experiments.

The Research is divided naturally into the examination of meteoric stones and meteoric irons. I propose at present to deal with meteoric stones or aerolites. These wonders of the sky consist generally of one or more silicates (mainly olivine and bronzite), interspersed with particles of nickeliferous iron, troilite, &c. Recent developments have led to many original devices and modification of details in the working spectrograph, thus furnishing information which may be of interest to those engaged on this branch of spectroscopic analysis.

As the whole value of the Research depends upon the excellence of my Spectrograph I propose to describe certain novel features of the Instrument. In previous papers I have already made brief reference to it, and therefore there is no need to describe it completely. It is peculiar in this respect; it has been devised and constructed in my laboratory for the work it was required to do, by a process of evolution, each part having been modified and improved as the work went on—thus in its present form it is the outcome of a great deal of experimental construction under working conditions. As an instance, I may say that the slit has been reconstructed at least six times—each change that the working conditions has rendered necessary making it more efficient until now it approaches perfection.

THE SPECTROGRAPH.

The instrument was originally devised for the photography of the ultra-violet region, but was ultimately extended so as to include the visible spectrum down to the limit of sensibility of the commercial panchromatic plate which is in the neighbourhood of λ 7000 A.U.; the two main aims in the whole construction were, first, that the definition of the lines should be pushed to the highest stage of perfection; secondly, that the mechanical construction should be such that the adjustments once made any number of spectra could be obtained without uncertainty in the excellence in definition. When I commenced to build the instrument I was greatly assisted by the advice and suggestions of the late Victor Schumann. Although the instrument is very different in design to any constructed by him, still the experience he had gained in his researches upon the spectroscopy of the ultra-violet region, which he freely placed at my disposal, was of the greatest possible value.

Having decided upon the general plan, the instrument was built up, first temporarily in wood, afterwards permanently in iron and gun-metal—and set to work. This was in February, 1899, and since then it has been in continual use; some thousands of photographs having been made. During this period each detail of the instrument has been subject to a process of evolution and reconstruction, each step leading to some advantage demanded by actual work.

The parts of the instrument are all assembled upon a large truly surfaced cast-iron table measuring 31×51 inches; the dispersion is given by five excellent double prisms made of right and left handed quartz, each double prism consisting of two halves made respectively of left and right handed quartz, prisms such as were first used by Cornu to avoid double refraction.

* Read before the Royal Society Nov. 2, 1916. From the *Philosophical Transactions of the Royal Society*, A, ccvii., 411.

The objective and collimating lenses are simple plano-convex, 40 mm. in diameter and 700 mm. focus. The spectrum is thrown upon a celluloid film so curved that all the lines are at their true focus.

The dispersion by the five prisms is considerable, and with the collimating and object lenses used would involve a spectrum of some 24 inches in length. As there are both mechanical and optical reasons against the use of such a large sized plate it was decided to "build up" the complete spectrum in eight successive plates, involving a length of 3 inches for each step. The reason for this decision is simple; to obtain perfect definition of any line it must be in or very near to the "optical centre" of the instrument, *i.e.*, the imaginary line passing through the slit, the centre of the two lenses, the centres of the prisms, and the centre of the curvature of the plate; and it was found by many experimental photographs that the best definition over each three-inch film was obtained when the least refrangible line shown was in the position of minimum deviation. The many devices that from time to time have appeared in spectroscopic construction for rotating the prisms by link motion were rejected as uncertain and complicated—experiment having shown that the excellence of definition was maintained within a range of several inches on either side of the optical centre and position of minimum deviation. The exact "data" involving the focus, position of the spark, angle of the plate, and position of prisms and lenses to give the finest definition of the photographed lines were found experimentally, and when found their positions were engraved upon the instrument and recorded so that for future work the instrument could could be quickly set to give a photograph in perfect detail for any desired portion of the spectrum.

The Slit.

The slit—of necessity one of the most important parts of the instrument—has been subject to more alteration and modification than any other portion. On account of the close proximity of my chemical laboratory I decided at the outset to avoid the use of steel for this purpose; on this point I differed from Prof. Schumann, who was a

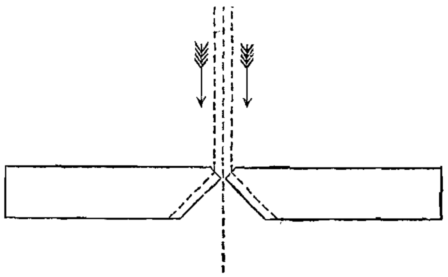


FIG. 1.

strong advocate of hardened steel jaws, and all his splendid photographs were made with spectrographs having steel slits. I obtained good results by using rolled metallic cobalt—very hard and non-corrosive—ultimately I hit upon the plan of employing quartz instead of metal (CHEMICAL NEWS, 1895, lxxi., 175).

I find this substitute answers so perfectly that I cannot imagine anything better.

At first I had great difficulty in getting the edge true. The sides and angle must be ground true and polished. It is difficult to fashion a knife-edge of quartz at an angle of 45°, because small splinters occasionally break off. Ultimately I got over this difficulty by putting a very narrow bevel on the front of the plate, so making the angle of each jaw 90°, thus (Fig. 1):—

Owing to refraction no light can get through the part of the quartz which is cut at an angle. The edge made in this way is absolutely black and opaque even in sunlight,

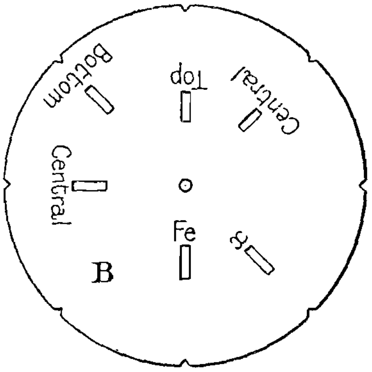
and should bear a high microscopic power without showing irregularity. To prevent light from coming through the flat part of the quartz plate, the surface, all but the extreme edge, is coated with gold by cathode deposition. It is very beautiful to see the absolute opacity and trueness of edge of one of these slits when examined under a high power.

Jaws made in this way have now been in continuous use for many years and give perfect satisfaction; they are absolutely unaffected by the atmosphere, can easily be cleaned, and with common care do not wear out.

The width of slit I use is small; for general work I use 0·008 mm. only, but for years this very fine width was a source of annoyance and anxiety, the reason being that it was necessary for purposes of adjustment, alignment of the spark, &c., to open the slit wide and then close it again. I found that even with the very best screws and construction there was always some uncertainty as to the absolute width of the slit used in any photograph—thus long. A is one of the brass blocks carrying the quartz jaws D; this block can be instantly attached or removed by a slight turn of the screw, and by the "hole, slot, and plane" device its position is invariable, as can be seen.

In front of the slit and attached to its place is a circular brass disc B; this disc completely covers the quartz jaws D; it is pierced with several openings, any one of which can, by a touch of the finger, be brought in front of the slit and held there by a spring which engages in a notch—(as shown in Fig. 3).

By these means light from various sources can be passed into the spectrograph through different portions of the slit and ultimately reaches the photographic film. For instance, in the particular work that forms the subject of this paper, the disc B is so fixed that the aperture marked Fe faces the slit, and the iron arc is projected upon it; then when a sufficient exposure has been given the disc is rotated so as to bring the aperture marked *x* opposite the slit, and the light from a silver-aerolite arc is passed in,



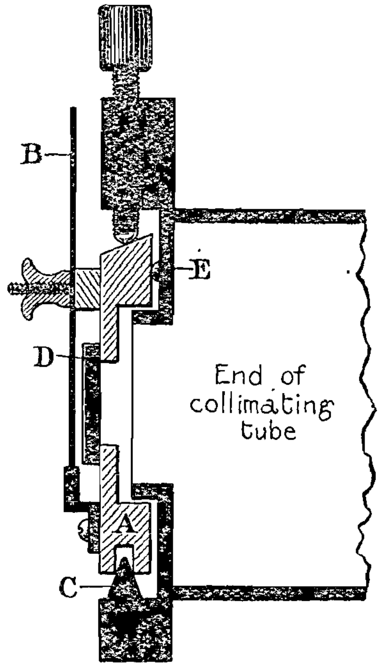


Fig. 2.

oducing annoying variations in spectra, made at different mes which should have been identical. During the first en years of work many slits were constructed, each showing a slight improvement; even then the uncertainty was not completely removed and the mechanical construction had become deeply complicated. Ultimately the difficulties were removed by the device that I call the *Fixed* slit system. This device gives perfect satisfaction and has the advantage of extreme simplicity.

The Fixed Slit System.

The such slits were prepared by taking brass blocks all of the same thickness, and upon each was permanently fixed a pair of quartz jaws set with openings of 0·008, 0·025, and 0·06 mm. respectively—these three widths being sufficient to embrace all the demands likely to occur.

The portion of the instrument upon which the slit is fixed is finished in the way shown in Fig. 2; it carries two pointed pins, one of which appears marked C, a steel stop E, and a screw; the whole is closed to light except for a small rectangular central opening 1 mm. wide and 10 mm. the resulting photograph shows two spectra slightly overlapping, one of iron and the other of the silver-aerolite. No disturbance of the spectrograph or of the photographic film occurs during the operation.

A front view of the slit plate A is shown in plan in Fig. 3; the dotted circle is the part covered by the disc.

The jaws do not wear or corrode. It is only necessary to clean and free them from dust by drawing between a sharply cut wedge of peg-wood. (Peg-wood splints are used by watchmakers to clean out pivot-holes in watches).

Before enumerating the metallic constituents of the aerolites I wish to place on record the outcome of a research which, although not giving the expected result, furnishes information that may be valuable.

In connection with the several theories as to the origin of Meteorites it was thought that a thorough examination of the occluded gases might possibly reveal the presence of some of the inert gases, or of those hypothetical elements thought to be present in some of the hotter stars. At the present time the manipulation and spectroscopic investigations of gases have reached a high state of de-

velopment, and a far more thorough investigation of the subject is possible than was the case years ago when much work was done by Prof. A. W. Wright, of Yale College (*Am. Journ Sci.*, 1876, 3rd series, p. 253).

It is now possible and comparatively easy to separate from the gaseous mixture liberated by heating the meteorite, the hydrogen, oxygen, carbon compounds, &c., whose presence is not indigenous, and to reveal any of the non-valent elements that may be present. One of the most popular methods is to employ the process of absorption by charcoal at low temperatures—the same method that has been employed with so much success upon the gases contained in spring waters, &c. There are, however, certain experimental and manipulative difficulties that I wished to avoid.

Some years ago Frederick Soddy, Esq., F.R.S., published an account of a device in which the absorption by metallic calcium at it volatilisation temperature was made

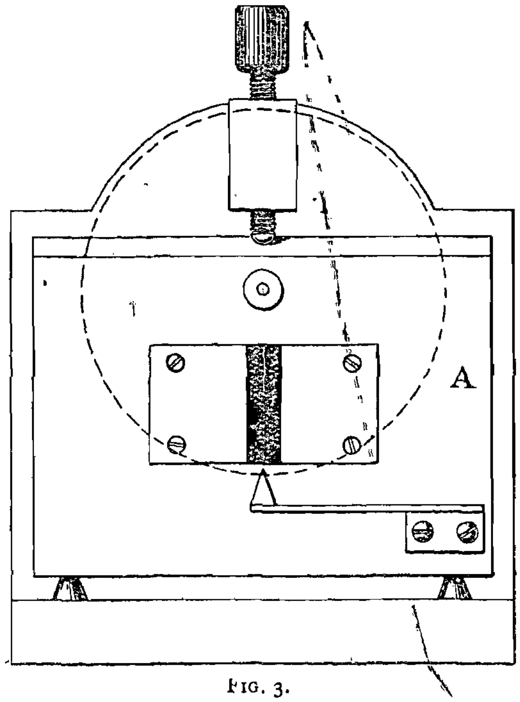


Fig. 3.

to answer the same purpose (*Proc. Roy. Soc.*, 1907, lxxviii., A).

Soddy's vacuum furnace, although a very ingenious piece of apparatus, is too elaborate for my purpose—so while adopting the principle I have modified the details.

The calcium cut into small fragments is placed in a small vessel of iron open at one end like a miniature test-tube and introduced into a similar but larger tube of fused quartz; it is then only necessary to attach the quartz tube to the pump and gas apparatus, and by applying a Meker burner so as to heat it to full redness the volatilisation of the calcium and subsequent absorption of the chemically valent gases are entirely under control.

By this means the gases—obtained by heating to redness each of the aerolites—were examined spectroscopically at different pressures. Fig. 4 gives an outline of the apparatus actually used. A special and simple form of Sprengel pump was made as shown, so that if needful it could be replaced by a new one for each meteorite. A is the vacuum tube; B the quartz tube with the iron vessel containing lumps of clean metallic calcium; C, a tube of hard glass, with the powdered aerolite; D, phosphoric acid to absorb moisture; E, an inverted tube filled with mercury, in which any gas not used could be collected.

The procedure was to exhaust thoroughly, and well spark the vacuum tube so as to expel any gas occluded in the electrodes, and continue the exhaustion until the tube ceased to conduct the current. The aerolite was then heated so as to expel the occluded gases, the pump set going, and the spectrum or the gas examined at various pressures down to about 20 mm.—when the pumping was stopped.

The calcium tube B was now strongly heated with a "Meker" burner; at first the gauge was depressed owing to gas liberated by the heat, and then absorption suddenly took place, and the gauge ran up to 1 or 2 mm. or less. The spectrum was kept under examination the whole time, and for convenience the spectrum given by helium was thrown on to the eye-piece by means of a right-angled prism, so that any indication of D_3, however faint, could be instantly observed.

Working in this way no indication whatever was found of the lines of any of the inert gases. The absorption in each case could be carried until the tube refused to conduct the current. The final lines observed before the tube ceased to be luminous were those of mercury—generally accompanied by a faint trace of the red line of hydrogen.

In each aerolite examination—after having satisfied myself of the absence of unabsorbable gases—a further quantity of gas was driven out by heat and the pressure adjusted to about 2 mm., the vacuum tube being sealed off at this pressure and kept with full particulars of its source for further reference.

The amount of gas that could be driven out of the aerolites by heat varied considerably. In some cases it was possible to expel several successive volumes of gas and each time to repeat the absorption by calcium; in other cases the amount of occluded gases was much less, but in all cases the calcium absorption was done at least *twice, so that a very minute percentage of the inert gases* would have been rendered visible.

When all the aerolites had been examined a final experiment was made to prove the efficiency of the method. A little samarskite was powdered and treated in the same way. On absorbing the liberated gases by heating the calcium—as soon as the pressure had been reduced to a few mm.—the complete spectrum of helium was revealed.

The only gases recognised were the compounds of carbon hydrogen, and in one or two cases only H_2S; this latter is somewhat remarkable, as at the time its spectrum appeared to be novel; the other aerolites were most carefully examined for it without success.

It was found impossible to get an induction spark to pass between two fragments of an aerolite, so attempts were made to make use of an arc. A fragment of the stone was ignited in a cup hollowed out of the lower carbon pole—the upper electrode being a carbon rod. As shown in Fig. 5, if an arc was struck between the two carbons by momentary contact with a third rod of carbon, the fragment of stone quickly became hot and ultimately fused and formed a molten sphere; the arc could then be maintained between this sphere and the upper carbon. Photographs were obtained of the resulting arc and the spectra of several of the meteoric stones examined. The plan followed was to arrange three stops or apertures that could be adjusted in front of the slit, and by their aid to project upon the photographic film, first the spectrum given by iron; then the spectrum of the aerolite ignited between two poles of carbon; and below that the spectrum given by carbon poles alone. In this way it was easy to observe any lines in the aerolite spectrum that did not appear in either the iron or the carbon, and thus the composition could be determined. This method was not altogether satisfactory owing to impurities in the carbon rods and the consequent uncertainity of some of the observed lines being due to constituents of the aerolite or to impurities in the carbon. I therefore tried other means.

(To be continued).

PROCEEDINGS OF SOCIETIES.

ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS.

The Third Annual Meeting of the Association was held in the Council Room of the Chemical Society at Burlington House on Thursday, July 10, followed in the evening by a Dinner at Princes' Hotel.

The Chairman, Robert Grosvenor Perry, C.B.E., in his speech at the Annual Meeting, reported a membership of 145 firms, representing a capital of about £70,000,000. In addition seven kindred associations are affiliated to the Association. During the year much useful work has been accomplished in consolidating the industry and strengthening the position of its various branches. The Chairman pointed out that we are only on the threshold of a great dye industry in this country, and the Council of the Association had paid close attention to this question. The Association has been recognised by the Board of Trade, and Dr. A. Ree and the General Manager, Mr. Woolcock, M.P., have acted as members of the Trade and Licensing Committee. In addition, Lord Moulton, the Honorary President of the Association, has accepted the Chairmanship of British Dyestuffs Corporation.

The importance of the manufacture of fine chemicals as a key industry has also been impressed on the Government, and the Association has been represented on an Imports and Exports Consultative Council which was set up as a temporary measure.

Close attention has been given by the Association to parliamentary legislation in so far as it affects chemical industry, and particular mention may be made of Patent Law and traffic problems.

A strong commission of the Association, representative of all branches of the industry, has recently returned from, and reported comprehensively upon, their visit, under Government auspices, to the chemical factories in the occupied area of Germany.

It is interesting to note that during the year an *entente cordiale* has been established between the British and French chemical industries, and collaboration between the two should be to their mutual advantage. After touching on many matters of domestic interest, the Chairman stated that he was called upon to give evidence before the recent Coal Commission and to give his views on the control of productive operations by public departments.

In the discussion which followed, appreciation was expressed at the work done by the Council, and it is evident that the chemical industry has derived great benefit from the activities of the Association since its formation in 1916.

In the evening a distinguished and representative gathering dined at Princes' Hotel, and among the guests of the Association were General Sir William Birdwood, Sir James J. Dobbie (President, Chemical Society), The Earl of Dunmore, Mr. T. G. Feasey, Lord Glenconner, General Hartley, Mr. J. Fitzallan Hope, M.P., Sir Herbert Jackson, Sir Evan Jones, Mr. F. G. Kellaway, M.P., Sir Arthur Steel Maitland, M.P., Rt. Hon. Sir Alfred Mond, Rt. Hon. Lord Moulton, and Mr. R. T. Nugent.

The toast to H.M. Ministers was proposed by Lord Moulton and responded to by Sir Alfred Mond. Lord Moulton expressed his terror in the early days of the war at the lack of important chemical industries vitally necessary ot save this country from defeat, and wondered to what extent the nation realised the importance of this industry.

In proposing the toast to the Association, Mr. F. G. Kellaway enlarged upon the remarkable achievements of British chemists and the wonderful part played by the industry as a whole. The toast was suitably responded to by Mr. Max Muspratt.

Dr. C. Carpenter, Vice-President of the Association, proposed the toast to Our Guests, which was responded to by the Earl of Dunmore and General Sir Wm. Birdwood.

The toast to the Chairman was felicitously proposed by Sir William Pearce, M.P., and briefly responded to.

COUNTY BOROUGH OF WEST HAM.

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GEORGE E. HILLEARY,
Town Clerk.
Education Department,
95, The Grove, E. 15.

G. R.

BY DIRECTION OF THE DISPOSAL BOARD, MINISTRY OF MUNITIONS.

Note.—For detailed list of all surplus Government Property for sale apply at the nearest bookstall, or to the Director of Publicity, Ministry of Munitions, Whitehall Place, S.W. 1, for "Surplus," price 3d.

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2 Earthenware Blow Eggs, tested to 80 lbs. pressure.

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Tenders to be endorsed "Tender for Stoneware," and reference number quoted in all cases.

Tender Forms, Schedules, and particulars can be obtained from the Controller, at the above address,

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J. R. PARKINSON, SON and HAMER have received instructions from the Executor of the late Mr. George Pilkington to Catalogue and SELL BY AUCTION at the Temperance Hall, Bury (where the goods will be removed for better convenience of sale), on Thursday, July 31, 1919,

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CATALOGUES may be had four days prior to Sale on application to the AUCTIONEERS, 16, Market Street, Bury, Lancashire (Tele. 547), or to—

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THE CHEMICAL NEWS

Vol. CXIX., No. 3094.

NITROGEN AND OTHER COMPOUNDS IN RAIN AND SNOW.

By JACOB E. TRIESCHMANN.

The importance of analysing the rain and snow for nitrogen and other compounds is widely recognised, both for its agricultural and hygienic significance. Messrs. F. T. Shutt and R. L. Dorrance, of Ottawa, Canada, carried on a systematic investigation of the rain and snow covering a period of ten years, 1908—1917, the results of which have added much to our knowledge of the importance of the nitrogen compounds as an agricultural factor.

Our purpose has been to determine the amounts of the different nitrogen compounds, the chlorine, sulphates, and phosphates, in the rain and snow of this locality—a continuation of the work which has been carried on here for a number of years, the results of which have appeared in the Chemical News from time to time.

The work was carried out in the Cornell College laboratories under ordinary laboratory conditions. It covers a period of eight and a half months, October 1, 1918, to June 15, 1919. The samples were collected in granite pans on an open spot near the centre of the town, which has a population of about 2500. The town is without manufacturing industries, which eliminates excessive smoke contamination of the air. Every precaution was taken to prevent contamination. Samples were collected immediately following the precipitation, and analysed as soon thereafter as was possible.

Altogether 46 samples were investigated, of which 36 were rain and 10 were snow. This represents 22·25 inches of rain, considering 12 inches of snow equivalent to 1 inch of rain. The precipitation has supplied during the period 511·74 pounds of chlorine equivalent to 842·15 pounds of sodium chloride; also 1·509 pounds of sulphates as SO_3, and 5·2790 pounds of nitrates per acre. The phosphates as P_2O_5 amounts to only 0·0086 pound per acre.

Only 15 samples produced sufficient sulphates for determination, the highest of which, on February 28, contained 0·262 part per million; and only 11 other samples showed a slight trace. The average for the period is 0·03 part per million. An unusually mild winter, with the atmosphere comparatively free from smoke and soot, possibly explains this low average.

Five samples showed a trace of phosphate, while only four supplied a sufficient quantity for determination, the highest of which, on March 4, was only 0·03 part per million. The average is 0·002 part per million.

The chlorine content averages 11·12 parts per million, varying from 6·10 to 25·70 parts per million. Its presence in the atmosphere has been ascribed by Dr. N. Knight to salt particles carried by the winds from the Atlantic Ocean. No increase was experienced due to wind preceding or accompanying a precipitation.

The average of total nitrogen supplied for each precipitation is 1·046 parts per million. The totals for the 46 precipitations are fairly constant. Strong wind and severe electrical discharges on March 6, and on June 1 and 3, did not increase the amounts of nitrogen, but the total nitrogen supplied on these dates is unusually high, especially on May 6 and 7, the highest of the period.

The average part per million for free ammonia is 0·407; for albuminoid ammonia, 0·366; for nitrates, 0·255; and for nitrites, 0·018.

Of the total nitrogen supplied during the period, 38·85 per cent is in the form of free ammonia, 34·99 per cent albuminoid ammonia, 24·42 per cent nitrates, and 1·74 per cent nitrites.

The amount of the precipitation determines largely the total number of pounds of nitrogen supplied per acre. Yet an examination of the pounds of nitrogen supplied per acre by each of the 46 precipitations reveals a remarkable uniformity. When reduced to pounds per acre for one inch of rain, 43 of the 46 precipitations come within the narrow limits of 0·15 to 0·40 pound per acre. The wide variation in the amounts of rain, 0·05 to 2 inches, indicates a marked degree of concentration in the smaller showers. The same standard reveals that during continued precipitations, as occurred June 1 to June 6, the total nitrogen supplied gradually diminished, in this case from 0·40 to 0·20 pound per inch of rain.

There is a gradual increase in the amount of precipitation from October to 0·50 of an inch, to June with 4·6 inches for the first half of the month.

Beginning with February, there is a gradual increase of total nitrogen in parts per million 0·699 to 1·134. This with the increased amount of rain in inches, furnishes an increasing supply of nitrogen per acre to the soil during the main growing season. The increase in pounds per acre during this period is from 0·3057 pound in November to 1·3078 in June.

The 45 inches of snow supplied 13 per cent of the total 5·2790 pounds of nitrogen per acre, or 0·6911 pound. The rains supplied 87 per cent or 4·5879 pounds per acre. The rain is shown to be richer in total nitrogen content than the snow.

The work of Messrs. F. T. Shutt and R. L. Dorrance, mentioned above, has been of assistance in summarising the results.

Grateful acknowledgment is made of valuable assistance rendered by Dr. N. Knight in carrying out this work.

Cornell College, Mount Vernon, Iowa,
July 5, 1919.

AN ALIGNMENT CHART FOR THE SOLUTION OF MOLECULAR WEIGHT AND VAPOUR DENSITY PROBLEMS.

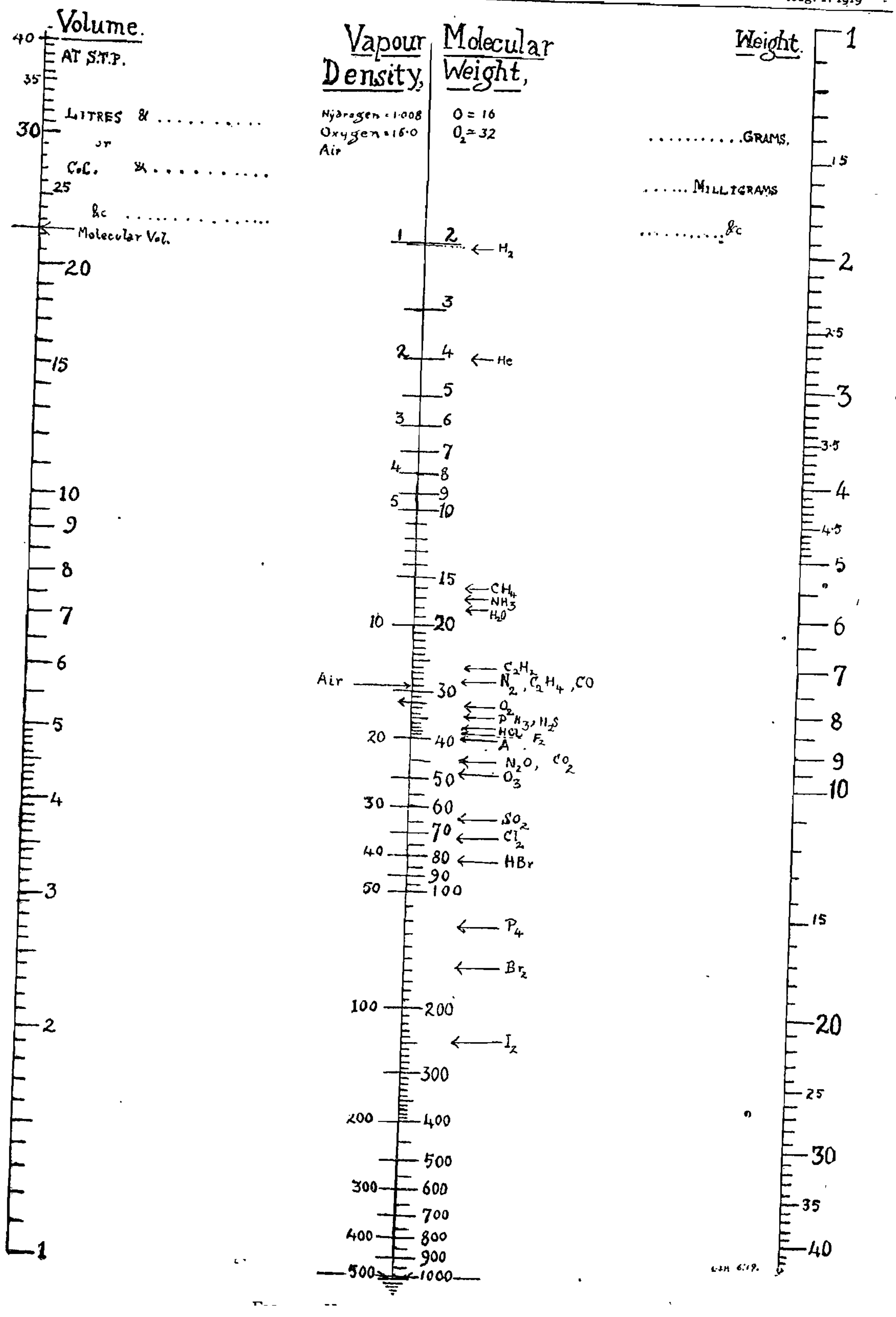
By LESLIE J. HARRIS.

A very frequent method of estimating the molecular weight of a volatile substance is by means of a determination of its vapour density. It was pointed out by Avogadro in 1811 that if, as his hypothesis asserts, equal volumes of different gases under the same conditions of temperature and pressure contain the same number of molecules, then the molecular weights of these gases are proportional to their densities. Avogadro further showed that the molecule of hydrogen contained at least two atoms; he assumed that it contained two only, and not more. Hence its molecular weight was 2, and the densities of gases referred to hydrogen as unity when doubled gave directly the molecular weight. Subsequently it was shown by Kundt and Warburg that the molecule of mercury was monatomic, and this served to confirm Avogadro's assumption as to the diatomicity of hydrogen.

Since 2 grms. of hydrogen occupy at S.T.P. 22·234 litres, the weight of any other gas occupying the same volume will be its molecular weight in grms. compared with the standard $H_2=2$. It is now, however, the general practice to refer molecular weights to the standard $O_2=32$. On this scale the M.W. of hydrogen is 2·016. This weight of the gas in grms. and therefore the molecular weight of any other gas, will occupy at S.T.P. 22·412 litres.

If W grms. of a vapour have a volume at 0° and 760 mm. of V litres, its molecular weight m will be given by the formula—

$$m = \frac{W \times 22{\cdot}412}{V},$$


Volume.
AT S.T.P.
Litres & ....
or
C.C. & ....
&c ....
Molecular Vol.
Vapour Density,
Hydrogen = 1·008
Oxygen = 16·0
Air
Molecular Weight,
O = 16
O2 = 32
Weight.
..........Grams.
......Milligrams
..........&c
H2
He
CH4
NH3
H2O
C2H2
N2, C2H4, CO
O2
PH3, H2S
HCl F2
A
N2O, CO2
O3
SO2
Cl2
HBr
P4
Br2
I2
Air

and its density D compared with O = 16 by—

$$D = \frac{W \times 11 \cdot 206}{V}.$$

Often the vapour density of a gas as determined in experimental work is compared with air as unity and then multiplied by a constant factor to give its M.W.

To save the labour of calculation the writer has devised the alignment chart shown, whereby the molecular weight or vapour density can be read off directly from the weight and volume. Alternatively the weight of a given volume or the space occupied by a given weight of gas may be determined provided the density be known.

The chart is read by means of a straight edge (as of a ruler) or a stretched thread, or most accurately by a line engraved on a celluloid cursor. The line is made to coincide with the given values on two of the scales; the point of intersection on the third scale shows the required figure—weight, volume, density, or molecular weight, as the case may be.

The chart is constructed on the same principle as my "nomogram" for the calculation of added water in milk, to the description of which the reader is referred (Chemical News, 1919, cxviii., 99). The scales for weight and volume are divided logarithmically and are of the same relative size, but the former is drawn in a positive (downward) and the latter in a negative direction. Midway between these and of one-half the dimension is the scale for molecular weights; being elevated a distance corresponding to log 22·412 it gives the reading—

$$m = \frac{W}{V} \times 22 \cdot 412.$$

The scale for vapour densities is depressed a further distance log 2 so as to give the value ½ × molecular weight.

The "molecular volume," 22·412 litres, is marked on the left-hand scale. The molecular weights of some common gases are also indicated on the central scale.

It should be noted that corresponding standards of weight and volume must be chosen, either grms. and litres, or else multiples or submultiples of both; *e.g.*, mgrms. and cc.

If desired the graduations for weight and volume may be drawn on a sliding scale, as indicated in Fig. 2, in which case the alignment is performed automatically. In use the value for volume shown on the lower scale is made to coincide with that for weight on the upper scale; the reading opposite the arrow (at the molecular volume) is the required M.W. Alternatively, with the slide rule in a given position all corresponding values of weight and volume for a specified gas are in coincidence.

A chart similar to the above may be constructed to show the molecular weights of dissolved substances in dilute solution, from the depression of the freezing-points and the known *coefficients of molecular depression* for various solutes. The same applies to the molecular elevation of the boiling-point.

Ruled logarithmic paper may now be obtained from several dealers, and with its aid the drawing of such charts becomes a simple matter.

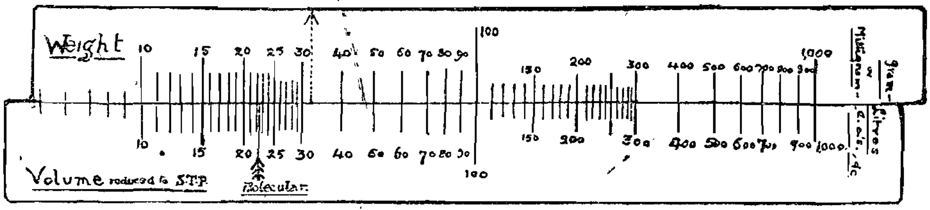


Fig. 2.—Harris's Molecular Scale.

THE RELATIVE STABILITY OF HALOGEN SUBSTITUTED ALIPHATIC ACIDS IN WATER SOLUTION.*

II. The Propionic Acid and Butyric Acid Series.

By G. S. SIMPSON.

In a recent paper from the Kent Chemical Laboratory of Yale University (Drushel and Simpson, *Am. Journ. Sci.*, 1917, xxxix., 2453), the relative stability of halogen substituted acetic acids as determined by the hydrolysis of their sodium salt s was discussed. This article describes the result of a similar investigation of the stability of several halogen substituted acids in the propionic and butyric acid series.

Preparation of Materials.

The ethyl esters of α-bromobutyric acid and α-bromoisobutyric acid, which were in stock, were readily purified by distillation. All other acids or esters were prepared as described below.

α-Chloropropionic ester was made from lactic acid by the method of Loven (*Journ. Prakt. Chem.*, 1884, [2], xxix., 367). Dried calcium lactate was allowed to react with phosphorus pentachloride and the α-chloropropionyl chloride obtained was added to absolute alcohol to form the ester. After purification the product boiled at 145—147°.

α-Bromopropionyl bromide was made by adding bromine to dry propionic acid in the presence of red phosphorus according to Zelinsky's method (*Ber.*, 1887, xx., 2026). This was added to absolute alcohol to form α-bromopropionic ester, which, after purification, boiled at 157—159°.

β-Iodopropionic acid was prepared by heating iodine and yellow phosphorus with an aqueous solution of glyceric acid, obtained by the oxidation of glycerin with fuming nitric acid and purification by means of its calcium salt. This method of purification of glyceric acid, suggeeted by Drushel (*Am. Journ. Sci.*, 1915, xxxix., 113), gives a crystalline product which is much more convenient to isolate and wash than the gelatinous lead salt. The iodopropionic acid was obtained as pearly white plates by recrystallisation from hot water.

β-Bromopropionic acid was formed by adding an aqueous solution of β iodopropionic acid to bromine and subsequent heating according to Richter (*Zeit. Chem.*, 1868, 461). The free iodine formed was filtered off and all excess of halogen was removed by pressing the product on a porous plate. It was purified by recrystallising from petroleum ether giving pearly plates melting at 62°.

β-Chloropropionic acid has been made by different methods by several investigators, but in each case a different melting-point was recorded. De Barr (*Am. Chem. Journ.*, 1899, xxii., 336) and Richter (*loc. cit.*) prepared it by the replacement of iodine of β-iodopropionic acid in aqueous solution with chlorine. The product was then distilled several times over mercury or silver. Such a procedure might easily give adipic acid according to this equation—

$$2ClCH_2—CH_2COOH + 2Ag \rightarrow (CH_2\text{-}CH_2COOH)_2 + 2AgCl$$

* From the *Journal of the American Chemical Society*, xl., No. 4.

The acid prepared in this manner melted at 58—61° while all the other procedures gave products melting at 35·5° to 41°. As De Barr gave no analysis of his product it is difficult to determine the true value of his method. Since β-iodopropionic acid was the only material available at this time for the preparation of β-chloropropionic acid, the method described by Drushel (*Am. Journ. Sci.*, 1912, xxxiv., 69) for preparing esters of β-chloropropionic acid was used. Fifty grms. of β-iodopropionic acid were dissolved in 100 grms. of chloroform. This solution, which was well cooled, was treated with chlorine in the dark until no more iodine trichloride separated out. This precipitate was filtered on asbestos and the filtrate was placed in a vacuum desiccator over caustic soda. After distilling off the chloroform the remainder of free halogen was removed by pressing the product on a porous plate. On recrystallisation from petroleum ether 20 grms. of white pearly crystals melting at 39° were obtained. This product thus melted within the limits given by several investigators. On analysis the following figures were obtained—

Subst., 0·2160, 0·2320; AgCl, 0·2902, 0·3084.
Calc. for $C_3H_5O_2Cl$: Cl, 32·70. Found: 32·90, 33·25.

An attempt was made to prepare β-chloropropionitrile by the selective action of potassium cyanide on β-chloro-α-bromoethane, synthesised by the method of James (*Journ. Prakt. Chem.*, 1882 [2], xxvi., 380), but large amounts of vinyl chloride were produced due to the alkalinity of potassium cyanide.

The α,α-dibromopropionic acid was made by Drushel's (*loc. cit.*) modification of the method of Phillipi and Tollens (*Ann.*, 1874, clxxi., 315). Dry propionic acid was heated in a sealed tube with bromine and the tube opened to allow the escape of hydrobromic acid. An equal amount of bromine was again added and the heating continued. The product was freed from hydrobromic acid and free halogen by pressing on a porous plate and then was recrystallised from a small amount of water. The material melted at 61°.

The preparation of α,β-dibromopropionic acid required the use of allyl alcohol which was made by Koehler's method (*Bull. Soc. Chim.*, 1913, [4], xiii., 1103). By allowing allyl alcohol and bromine to stand in two crystallising dishes several days under a bell-jar, β,γ-dibromohydrine was formed as described by Munder and Tollens (*Ann.*, 1873, clxvii., 224). This product was steam-distilled and then oxidised to α,β-dibromopropionic acid by means of fuming nitric acid. The material after recrystallising from water melted at 63°.

α,β-Dichloropropionic acid was similarly made from allyl alcohol by Tollens' method (*Ibid.*, 1869, clvi., 147). The β,γ-dichlorohydrine formed by passing chlorine into a cooled flask containing allyl alcohol was distilled in a vacuum and then oxidised by fuming nitric acid to α,β-dichloropropionic acid. It was purified by washing and recrystallising from hot water, giving a product melting at 49°.

α-Chlorobutyric acid was obtained by the method of Freer (*Ibid.*, 1904, cccxix., 357). Ethyl malonic ester was formed by the action of ethyl iodide on sodiomalonic ester. This was chlorinated by Gutzeit's method (*Ibid.*, 1881, ccix., 232). The chloroethyl malonic ester was converted to potassium ethyl chloromalonate by an alcoholic solution of potassium hydroxide and from this the free acid was obtained by means of dilute sulphuric acid. On distilling ethyl chloromalonic acid in a vacuum (15 mm.) at 101°, carbon dioxide was split off and α-chlorobutyric acid passed passed over, as described by Freer (*loc. cit.*).

β-Chlorobutyric acid was made by saturating an ethereal solution of crotonic acid with hydrochloric acid gas according to De Barr (*loc. cit.*). After removing the ether β-chlorobutyric acid was distilled in a vacuum (22 mm.) at 116°. The crotonic acid was made by the method of Komnenos (*Ann.*, 1883, ccxviii., 145) by heating malonic acid, acetic acid, and paraldehyde together on a steam-bath.

TABLE I.—*Velocities of Hydrolysis of Sodium α-Chloropropionate, Sodium α-Bromopropionate, Sodium β-Bromopropionate, Sodium β-Iodopropionate, Sodium β-Chloropropionate, and Sodium α,α-Dibromopropionate in* 0·1 N *Solution at* 70°.

A. Sodium α-Chloropropionate.

t (min.).	Cc. 0·1 N NaOH.	Cc. 0·1 N $AgNO_3$	10^5 K.
0	0·10	0·10	—
180	2·45	2·98	126·0
360	3·50	3·95	89·1
780	6·48	6·90	85·5
1620	9·93	10·43	82·5
2250	11·23	11·70	78·5
3480	12·53	13·05	74·3
4800	13·12	13·42	62·5
∞	13·88	14·10	—

B. Sodium α-Bromopropionate.

0	1·22	1·30	—
15	3·60	3·77	1410
30	5·05	5·43	1270
60	7·60	7·85	1170
90	9·10	9·20	1040
120	9·65	10·03	945
180	11·03	11·33	835
240	11·50	11·65	682
∞	13·98	14·15	—

C. Sodium β-Chloropropionate.

0	0·30	0·50	—
30	2·60	3·15	651
60	3·95	4·90	581
90	5·10	6·30	545
120	5·90	7·30	505
180	7·35	8·75	442
300	9·00	10·40	353
480	10·40	11·85	295
∞	13·30	15·50	—

D. Sodium β-Bromopropionate.

0	4·15	4·60	—
5	6·15	6·60	4670
10	7·20	7·85	4060
20	8·55	9·45	3490
30	9·77	10·33	2980
40	10·40	10·95	2690
65	11·40	11·95	2240
120	12·57	12·88	1620
∞	14·10	14·30	—

E. Sodium β-Iodopropionate.

0	4·13	4·55	—
5	6·12	6·55	4330
10	7·15	7·78	4040
20	8·87	9·42	3470
30	9·80	10·30	3010
40	10·35	10·97	2720
65	11·48	12·00	2240
120	12·65	12·93	1650
∞	14·10	14·30	—

F. Sodium α,α-Dibromopropionate.

0	0·80	0·80	—
60	6·45	6·75	426
150	11·35	12·00	368
240	14·35	14·90	326
420	17·85	18·45	264
630	20·15	21·00	229
1080	23·00	23·58	196
1860	25·50	25·90	165
∞	27·15	27·18	—

It was separated from methyl glutaric acid, formed at the same time by removing the portion distilled over between 170—210°. This was purified by repeated distillation and recrystallised from hot ligroin giving a product melting at 71—72°.

When the esters were available, the sodium salts of halogen substituted aliphatic acids were obtained by treatment with a strong solution of caustic soda as previously described (*loc. cit.*). By this method sodium α-bromoisobutyrate separated out at once since it is quite insoluble in alcohol. In all other cases concentration of the solutions in a vacuum and subsequent isolation of the sodium salts was found necessary.

In cases where the free halogen substituted aliphatic acids were available they were simply neutralised by a calculated amount of 0·1 N solution of caustic soda free from sodium carbonate. These solutions were then hydrolysed as described below.

Hydrolysis of Sodium Salts.

The sodium salts of the above halogenated fatty acids were hydrolysed in 0·1 N solutions, using 15 cc. portions sealed in glass tubes as previously described (*loc. cit.*). In all cases, with the exception of sodium α-bromoisobutyrate, which was found to be very unstable, the temperature of hydrolysis was 70°. The values of K are based upon the silver nitrate necessary to precipitate the halide liberated at various time intervals by the usual titration formula for a monomolecular reaction.

$$K = 2{\cdot}3/tn\ [\log_{10}(T_\infty - T_0) - \log_{10}(T_\infty - T_n)].$$

Senter (*Trans. Chem. Soc.*, 1909, xcv., 1827) has previously discussed the hydrolysis of sodium α-bromopropionate at 32·4°, but has given no temperature coefficient. This work has been repeated to compare its stability with the stability of other salts at the same temperature. These experiments confirm his statement that the methyl group substituted in the α-position renders the compound less stable than the hemologous sodium bromoacetate.

Sodium α-chloropropionate is found to be more stable than sodium α-cbromopropionate, but it is less stable than sodium chloroacetate, which was discussed in the previous paper (*Journ. Am. Chem. Soc.*, 1917, xxxix., 2453).

The hydrolysis of sodium β-chloropropionate, sodium β-bromopropionate, and sodium β-iodopropionate, which have not been studied before, produce hydracrylic acid under the conditions of these experiments. It was found that these salts are much more unstable than the isomeric α-halogen substituted compounds. Of the three, β-chloropropionic acid is the most stable, while little difference exists between the stability of β-bromopropionic acid and β-iodopropionic acid. This shows that the position of the halogen has a greater effect on the stability of the acid than does the identity of the halogen. In the latter two salts it will be noted from Table I., D, E, that the reaction was about one-third complete before the solution reached the temperature of reaction. The great difference in the titrations with sodium hydroxide and silver nitrate is in accord with the recent work of Johannsen on the formation of β-lactones (*Ber.*, 1915, xlviii., 1262; *Chem. Zentr.*, 1916, II., 557).

(To be continued).

Importation of Chemicals.—The Board of Trade, Department of Import Restrictions, has agreed to the British Chemical Trade Association being represented on the Advisory Committee which is assisting the Department in connection with the issue of licences to import chemicals. Mr. William Mann, the President, has been elected by the General Committee to represent the Association. Members of the Association are invited to specify the chemicals which they are likely to import. If at any time they feel that they have cause for legitimate complaint in connection with licensing restrictions they should at once bring the matter to the notice of the Association

ON THE

PHOTOGRAPHIC SPECTRA OF METEORITES.*

By Sir WILLIAM CROOKES, O.M., F.R.S., LL.D., &c.

(Continued from p. 47).

The Slit (continued).

The aerolite was finely powdered and mixed with a metallic powder, the composition of which was known. The mixture was strongly compressed in a hydraulic press, and from the solid mass thus obtained a pair of poles were fashioned.

Iron was one of the first metals used for experiment, but was discarded owing to the fact that iron is a plentiful constituent of stony meteorites. Silver was finally chosen because of the comparative ease of getting it pure—also because the lines in any part of its arc spectrum are few in comparison with the lines of iron which are exceedingly numerous all along the spectrum. Moreover, the softness of silver makes it easy to get strongly coherent poles from

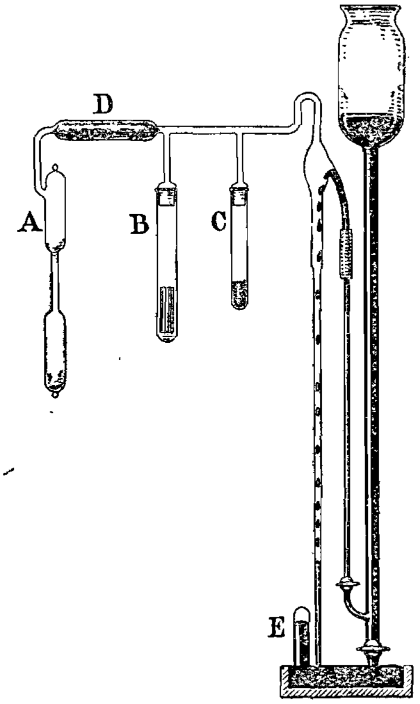


Fig. 4.

its mixture with the aerolite. The silver powder I used was specially prepared by a method given to me by Dr. A. Scott, F.R.S. The purest commercial silver was dissolved in nitric acid, the solution evaporated to dryness in a silica crucible, and the solid residue fused till any copper nitrate which might be present was decomposed. The mass was extracted with water, and the filtered solution of silver nitrate precipitated by means of a boiling solution of ammonium formate and acetate into which the silver solution was slowly run. After the liquid had become brilliantly clear and the silver well agglomerated, the metal was thoroughly washed and dried. The aerolite in fine powder was mixed with an equal weight of the silver, and the mixture slightly damped and compressed

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into a block in a hydraulic press at a pressure of 250 atmospheres. The resulting cake—after drying—was raised to dull redness, and was then cut across to form two poles between which to form the electric arc. The poles were mounted in special clips in a mechanical arrangement to enable the arc to be accurately focussed on the slit and kept there during the exposure.

The Arc Spectrum of an Aerolite.

In order to identify the different elements present I have worked by a method unlike that adopted by most observers. Instead of measuring the wave-lengths of the lines and establishing their identity by reference to published tables of wave-lengths, I have made it a rule to obtain, first, a qualitative idea of the constituents present, then to photograph the spectrum of the aerolite and silver mixture in juxtaposition with that of each suspected element by a device already described. In this way I have been able with certainty to identify every line in the spectrum of each aerolite examined. This removes the uncertainty

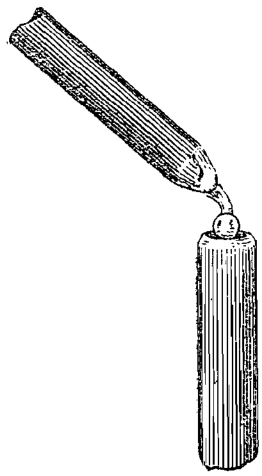

FIG. 5.

due to irregularities in the determination of wave-lengths by different observers. I can take no responsibility for the accuracy of the figures by which I identify these lines; they are copied from the most recent and trustworthy sources—had it been possible to reproduce the actual photographed spectra that I am now exhibiting there would have been no need to have printed any figures at all. The spectrum of the aerolite is easily distinguished from the mixed silver and aerolite spectrum by reference to a photograph of the silver taken separately.

The advantage of my method becomes apparent if—for illustration—I take one element—nickel—common to all meteorites. In the range of my instrument there are no less than three hundred and forty strong lines which I have identified, and on the aerolite spectrum I have marked all the nickel lines than can be seen, together with the wave-length given in the most recent determination —but the *point* is that any line marked is actually present as found by reference to the spectrum of pure nickel, and does not rest upon a coincidence of figures.

Examination of the Arc Spectra of Thirty Aerolites.

List of aerolites thus far examined:—

L'Aigle (from Orne, France). The photographed spectrum of this aerolite extends from λ 2973 to 5896, and includes in addition to the lines of iron 2 aluminium, 1 calcium, 23 chromium, 3 magnesium, 3 manganese, 27 nickel, 2 potassium, 6 sodium.

Alfianello (from Brescia, Italy). The photographed spectrum extends from λ 3018 to 6643, and includes in addition to the lines of iron 1 aluminium, 2 calcium, 23 chromium, 2 magnesium, 3 manganese, 40 nickel, 6 sodium.

Aubres (from Nyons, Drôme, France). There was great difficulty in maintaining the arc. The photographed spectrum extends from λ 2507 to 5896, and contains in addition to the lines of iron 10 chromium, 6 magnesium, 3 manganese, 6 nickel, 4 silicon, 2 sodium.

Baroti (from Bilaspur, Simla, Punjab, India). The photographed spectrum extends from λ 2851 to 5896, and shows in addition to the lines of iron 2 aluminium, 2 calcium, 25 chromium, 2 magnesium, 3 manganese, 2 potassium, 4 sodium, 38 nickel.

Barratta (from Deniliquin, New South Wales). The photographed spectrum of this aerolite extends from λ 2853 to 5206, and shows in addition to the lines of iron 2 aluminium, 2 calcium, 26 chromium, 3 magnesium, 3 manganese, 29 nickel, 2 sodium.

Bustee (from India). The aerolite behaves in a very similar way to El Nakhla el Baharia, and it was only possible to obtain one photograph. Very few lines were found, and these were chiefly those due to chromium and magnesium; the lines of nickel cannot be seen. In addition to the lines of iron the following were identified between λ 2852 and 4289, 2 calcium, 10 chromium, 6 magnesium, 3 manganese, 2 sodium.

Chandakapur (from Berar, India). This is a very rare aerolite, and as I had only 2·184 grm. of the material very great care had to be taken in obtaining the spectrum. The photographed spectrum extends from λ 2507 to 6643, and contains in addition to the lines of iron 1 aluminium, 3 calcium, 36 chromium, 7 magnesium, 3 manganese, 43 nickel, 6 silicon, 6 sodium.

Chantonnay (from Vendée, France). The photographed spectrum of this aerolite commences at λ 2551 and extends to λ 5896, and contains in addition to the lines of iron 2 aluminium, 1 calcium, 18 chromium, 2 magnesium, 3 manganese, 27 nickel, 2 potassium, 6 sodium.

Chateau-Renard (from Triguères, Loiret, France). The photographed spectrum of this aerolite extends from λ 3230 to 5896, and includes in addition to the lines of iron 2 calcium, 28 chromium, 2 magnesium, 3 manganese, 44 nickel, 2 potassium, 6 sodium.

Crumlin (from County Antrim, Ireland). The quantity of material in this case was small, the lines in the photographed spectrum extend from λ 2967 to 5896, and includes in addition to the lines of iron 2 aluminium, 31 chromium, 2 magnesium, 3 manganese, 38 nickel, 6 sodium.

Dandapur (from Goruckpur, North-west Provinces, India). The photographed spectrum of this aerolite commences at λ 3002 and extends to 5896, and includes in addition to the lines of iron 1 calcium, 24 chromium, 2 magnesium, 3 manganese, 47 nickel, 2 potassium, 4 sodium.

Daniel's Kuil (from Griqualand East, South Africa). The photographed spectrum of this aerolite commences at λ 2788 and ends at 6634, and includes in addition to the lines of iron 1 aluminium, 30 chromium, 3 magnesium, 3 manganese, 49 nickel, 6 sodium.

Dhurmsala (from Kangra, Punjab, India. The whole of the material available, 5 grms., was used and the photographed spectrum extended from λ 2795 to 6643, and includes in addition to the lines of iron 2 calcium, 28 chromium, 5 magnesium, 3 manganese, 38 nickel, 2 potassium, 6 sodium.

Durala (from Kurnal, Punjab, India. The photographed spectrum of this aerolite extends from λ 2975 to 5896, and includes in addition to the lines of iron 2 calcium, 19 chromium, 4 magnesium, 3 manganese, 37 nickel, 2 potassium, 4 sodium.

Eli Elwah (Hay, Waradgery County, New South Wales. The photographed spectrum extends from λ 3246 to 4957,

and includes in addition to the lines of iron 7 chromium, 2 magnesium, 3 manganese, 27 nickel, 2 sodium.

El Nakhla el Baharia (from Alexandria, Egypt). This very sort stone when mixed with silver powder and compressed into a block proved to be very fusible and the arc could only be maintained for a few seconds, three short exposures only were obtained, and these were not sufficient to bring out the nickel lines. The photographed spectrum extends from λ 3466 to 5896, and includes in addition to these lines of iron 9 chromium, 2 magnesium, 3 manganese, 2 potassium, 4 sodium.

Futtehpur (from North-West Provinces, India). The photographed spectrum extends from λ 2852 to 5896, and includes in addition to the lines of iron 2 aluminium, 3 calcium, 31 chromium, 4 magnesium, 3 manganese, 48 nickel, 2 potassium, 4 sodium.

Gilgoin (from Brewarrina, Clyde County, New South Wales). The lines showed in the photographed spectrum of this aerolite extends from λ 2598 to 5896, and includes in addition to the lines of iron 3 calcium, 24 chromium, 6 magnesium, 3 manganese, 37 nickel, 2 potassium, 6 sodium.

Girgenti (from Sicily). The photographed spectrum extends from λ 2852·2 to 5896, and includes in addition to the lines of iron 2 aluminium, 4 calcium, 25 chromium, magnesium, 3 manganese, nickel, 2 potassium, 4 sodium.

(To be continued).

CHEMICAL ACTION PRODUCED BY RADIUM EMANATION. II.*

The Combination of Hydrogen and Oxygen.

By S. C. LIND.

(Concluded from p. 44).

7. *Action of α-Rays on the Pure Components.*

The limit of changing the proportion of the two gases wil be pure oxygen or pure hydrogen. According to the earlier results of the writer (*loc. cit.*), under different experimental conditions, ozone is formed by the action of α-particles on pure oxygen, and in the present case a secondary reaction between this ozone and the mercury of the manometer might be expected, and is indicated by the results near the end of reactions in Table IV. for the second and third experiments. Scheuer (*loc. cit.*) found that emanation mixed with oxygen led to very little pressure reduction, but it was not stated whether this reaction took place in the presence of mercury

Direct experiments with pure oxygen, using the apparatus of Fig. 1, have shown that a decided diminution in pressure does take place, but that the velocity is dependent upon the surface of mercury exposed. If the surface is only that exposed by the mercury ordinarily in the stem of the reaction bulb at *e* the reaction is relatively slow, but if the mercury is allowed to rise in the bulb and spread out the action increases many fold. This probably means that primary ionisation takes place in all cases, but that deozonisation also takes place unless the opportunity for ready combination with mercury is favourable. The surface of the mercury becomes black, loses its coherence, clings to the glass, and is covered finally with a black powder, apparently mercurous oxide. The actual experimental data for the diminution of oxygen pressure will not be presented here as the work must be regarded as preliminary only.

In the case of pure hydrogen a smaller diminution in pressure was also found to result, accompanied by a darkening of the mercury and loss of coherence, though no powder becomes visible on the surface as in the case with oxygen. The diminution of pressure ceases after a time, and could not be made to proceed further by exposing a greater mercury surface. To explain reduction of pressure in the case of hydrogen several possibilities present themselves. Usher (*Journ. Chem. Soc.*, 1910, [I.], xcvii., 389) found, in trying to cause hydrogen and nitrogen to unite, that the reduction in pressure was mainly due to driving hydrogen into the glass wall by the α-particle. Duane and Wendt (*Phys. Rev.*, 1917, x., 116) have discovered the existence of an active modification of hydrogen produced by radium emanation, which may be H_2, or possibly H found by Langmuir (*Journ. Am. Chem. Soc.*, 1912, xxiv., 1310). The loss of hydrogen in the present case may then be mechanical, in which connection it may be pointed that when the reduction in pressure had ceased, heating the bulb with free flame liberated part of the hydrogen again, either from the glass or the darkened mercury clinging to it. Most of the liberated hydrogen again disappeared over-night. That the effect cannot be wholly on the glass walls is proved by the change in the property of the mercury, which suggests that the active hydrogen can react, either with mercury or possibly with some more basic impurity present in the mercury in small amount, to form an hydride.

Neither in the case of pure oxygen nor pure hydrogen can these results be considered as anything more than preliminary. The experiments will be repeated under more exact conditions. They were undertaken to show whether side reactions with the separate components might possibly disturb the main course of the reaction. While the possibility is apparent it is not believed that such disturbances are serious for the following reasons:—First, the active forms of hydrogen or oxygen appear to react more readily with each other than to enter into side reactions. This is evident from the fact that reaction sometimes proceeds to 99 per cent of completion, which would hardly be the case if either component had been permanently removed. Also the mercury never shows these marked changes in property in the presence of equivalent quantities of hydrogen and oxygen. Finally when either component is exhausted the reaction velocity sinks to a low order not possible to confuse with the ai reaction (see Table IV., 2nd and 3rd reactions).

8. *Ratio of Chemical Action to Ionisation.*

Having established a general law for the reaction between hydrogen and oxygen, and shown that it holds for all spherical volumes up to the largest diameter investigated (5·6 cm.) and also for a cylinder (4 × 1·8 cm.), the way is open to evaluate the statistical ratio of the actual number of molecules reacting (M) to the number of pairs of ions (N) produced by α-radiation. In Section 5 it was shown that $k\mu/\lambda = 84 \cdot 1/D^2$

For a sphere with D = 1, $k\mu/\lambda = 84 \cdot 1$.

λ = transformation constant of Ra emanation = $2 \cdot 085 \times 10^{-6}$ sec^{-1}. μ = efficiency factor for the chemical effect of the ion (S. C. Lind, *Journ. Phys. Chem.*, 1912, xvi., 592), and may be expressed as—

$$\mu = (M/N).(760/V.2 \cdot 75 \times 10^{19}).$$

k = ionisation coefficient = number of α-particles per second for 1 curie of emanation in equilbrium with Ra A, B, and C ($= 3 \times 3 \cdot 57 \times 10^{10}$) (Rutherford, *Phil. Mag.*, 1914, [VI.], xxviii., 320) × number of ions for 1 α-particle per 1 cm. of path ($2 \cdot 2 \times 10^4$) × specific ionisation of gas mixture (for $2H_2—1O_2$: $\frac{1}{3}[2 \times 0 \cdot 24 + 1 \cdot 90] = 0 \cdot 509$) × average path (for sphere of 1 cm. diam. = 0·348) × 1/760 (to refer to 1 mm. of pressure).

Therefore,—

$$k = 4 \cdot 29 \times 10^{14}.1/760.$$

Substituting in $k\mu/\lambda = 84 \cdot 1$ and solving for M/N—

$$M/N = 5 \cdot 87, \text{ or } M_{H_2O}/N = \tfrac{2}{3}M/N = 3 \cdot 92.$$

That is to say, for each pair of ions produced in the

* Published with permission of the Director of the U.S. Bureau of Mines. From the *Journal of the American Chemical Society*, xli., No. 4

gaseous mixture $2H_2+1O_2$, *3·92 molecules of water are formed.*

Before discussing this result some consideration of the method of determining the average path of the α-particles is necessary. The theory has already been developed by the writer (*loc. cit.*), and the earlier value of the average path from all points within a spherical volume (0·798 × radius) was obtained by calculating from 10 concentric spheres dividing the whole into 10 equal volumes. By using 100 instead of 10 spheres a more exact value has now been obtained, $0·8138 \times r$. Making the same assumption as before that practically all Ra A and Ra C diffuse to the wall before decaying the effective average of all paths is—

$$r/3(0·8138+2\times 0·6366) = 0·6957\ r.$$

The assumption that Ra A and Ra C have time to diffuse to the wall before emitting their α-radiation is one requiring consideration. No data having a very direct bearing on the subject has been found in the literature. A. Debierne has made the most complete examination of the diffusion of the radio-active deposit by using parallel plates at different distances apart exposed to emanation (*Le Radium*, 1909, vi., 97). His results showed that the practical limit of diffusion is much less than the theoretical, indicating a particle 140 times as heavy as the atom of the decay products. Debierne also found that increase of concentration of the emanation diminishes the diffusion limit. Since the present experimental conditions were so different from those of Debierne as regards volume and concentration of emanation, it appeared advisable to make a few direct experiments by allowing the emanation to reach equilibrium in a vessel and gas mixture exactly the same as employed in the velocity measurements, and then suddenly displace the gas by mercury into a new vessel in which the rise of the α-radiation would disclose the quantity of Ra C transferred. The result showed that in a bulb of 2 cm. diameter filled with $2H_2+O_2$ at atmospheric pressure and containing 126·5 millicuries of emanation, 98·3 per cent of the Ra C is deposited on the wall of the original vessel, since only 6·7 per cent passed into the new one. For a 6 cm. bulb 88·4 per cent remains on the wall of the original vessel. This result, not to be expected from Debierne's data, is probably due to convection arising from the much higher concentration of emanation. At any rate it is evident that even in a 6 cm. bulb a large part of the Ra C reaches the wall before decaying. This would not necessarily be true for Ra A in large bulbs, owing to its much shorter life, but one must not lose sight of the fact that the velocity constants (*cf.* Table II.) do not indicate any difference between large and small bulbs as to the effectiveness of the emanation (plus decay products). Therefore, whatever assumption as to position of decay products is made for one size must be made for all. The most plausible assumption is then that about the same portion of Ra A and Ra C reaches the wall in all sizes used, and the writer has therefore kept the original assumption that practically all α-particles from Ra A and Ra C originate at the wall. However, to assume that only part of the Ra A, even a small part, reaches the wall would not greatly change the value of the average path.

9. *Discussion of Results.*

From the kinetic standpoint the reaction between hydrogen and oxygen when brought about at ordinary temperature by radium emanation proceeds with great regularity. This is a decided contrast with the thermal action of the same gases at higher temperatures, which has hitherto baffled all investigators in attempting to study the kinetics, on account of the extreme irregularity of the reaction.

Although the action of radium emanation is frequently referred to as *catalytic* in nature, it can no more be properly termed so than can the effect of the electric current in producing chemical action. Each produces a definite amount of action having a definite relation to the electrical quantities concerned.

The effect on the velocity of varying the proportions of hydrogen and oxygen is of importance especially as it shows more strikingly the parallelism to ionisation. The greater the proportion of oxygen the faster the reaction, because the greater its ionisation compared with hydrogen.

Since the temperature coefficient of ionisation is zero through quite wide limits, one would expect a chemical reaction resulting from ionisation also to have a temperature coefficient equal to zero. Through two parallel experiments, one at 25° and the other at 0°, this has been shown to be the case over this range. This, of course, has no bearing on what the temperature effect might be outside this limited range, but is mentioned to show that the neglect of constant temperature conditions does not introduce error in carrying out the velocity measurements at room temperature. This is very fortunate as it would be much more inconvenient to make the measurements in a thermostat.

In order to compare these results with those of Scheuer (*loc. cit.*), Equation 1 was applied to his data, obtaining an experimental value of $k\mu/\lambda$ which can be compared with one calculated from the size of his bulb, using the general relation $k\mu/\lambda = 84·1/D^2$. From Scheuer's Experiment II. (D = 7·18 cm.; P_0 = 1580 mm.; P_{final} = 1433·8 mm.), $k\mu/\lambda$ (found) = 1·601, calculated 1·633. For his Experiment III. (D = 8·94 cm.; P_0 = 1680 mm.; P_{final} = 1518 mm.), $k\mu/\lambda$ (found) = 0·987, calculated 1·054. For II. the agreement within 2 per cent with the writer's results may be regarded as very satisfactory. In III. the value from Scheuer's data begins to drop below theoretical, owing to the effective diameter of Scheuer's large bulb with high gas pressure exceeding the range of some of the α-rays, thus making the prediction higher than the actual. This effect becomes predominant for Scheuer's Experiment IV. (D = 6·0; P_0 = 11445 mm.), where $k\mu/\lambda$ (found) is only 0·3278, compared with the calculated value 2·278. For some reason not apparent the agreement with Scheuer's Experiment I. is not good; the reaction is higher than theory, but should be considerably lower owing to the size of the bulb (13·78 cm. diam.). It is of great interest, however, that two of Scheuer's experiments agree with the writer's as to the amount of reaction for the quantity of emanation and size of bulb employed, and a third, which is outside the range to which the writer's theory is applicable, varies in the right direction.

The agreement for the value M/N between Scheuer and the writer may also be regarded as satisfactory, when it is considered that the methods of calculating N, the ionisation, were quite different. The average of Scheuer's 4 values with emanation mixture with the gases is 5·51 and the writer's 5·87. Scheuer states he used the Duane and Laborde formula for calculating ionisation, but not enough details are given for the writer to be able to follow the calculation, and unfortunately the promised full report of Scheuer's work did not appear before he fell early in the war.

Comparison of the present results with those of Cameron and Ramsay cannot be fairly made without recalling the fact that Cameron and Ramsay's pioneer work was regarded by them only as preliminary in nature. It was carried out when the proper conditions for handling radium in solution and for collecting and measuring the emanation were not thoroughly understood. Their kinetic equation has been shown to be (Section 3) a special limiting case of the more general form. They made no calculations as to ionisation. The quantity of reaction which they found in a tube of given size is several times below that found by Scheuer or the writer, doubtless due to the inefficiency of the collection of their emanation. This can be readily understood from the fact that their radium was not guarded in solution by protective acid, and from a footnote (*loc. cit.*, p. 97) it appears that part of their radium was in the form of sulphate and carbonate, salts very insoluble in neutral solution, which would therefore liberate much less than the theoretical quantity of emanation. To illustrate the above statements their Experiment IV. in a volume of

2·186 cc. gives a value of 12·7 for $k\mu/\lambda$, which should be for that volume 32·43. For their Experiment VI. in a volume of 4·996 cc. $k\mu/\lambda = 6·9$, but should be 16·03.

Further values for M/N for other gas reactions calculated from the data of Cameron and Ramsay are probably in error by a similar amount, but it would hardly be safe to assume and use a correction factor. The experiments themselves should be repeated, which the writer hopes to be able to undertake in the near future.

Any discussion of the possibility of giving theoretical significance to the M/N value of 3·92 will be reserved for the conclusion of the next paper, Part II.

10. *Summary.*

The foregoing experiments on the combination of hydrogen and oxygen gases at ordinary temperatures under the influence of radium emanation mixed with the gases in spherical vessels of different diameters show:—

1. The velocity of reaction in a given volume is dependent on two variables only, the quantity of emanation E and the gas pressure P. The velocity constant obtained by integration of the equation arising from this assumption has been verified. Its form is—

$$\text{const.} = (\log P/P_0)/E_0(e^{-\lambda t}-1).$$

2. The effect of increasing the spherical volume is to diminish the velocity constant (expressed in terms of pressure) according to the equation, const $= 84·1/D^2$, where D is the diameter in cm. This is to be expected from the increase of the average path of the α-particle proportional to D, while the pressure effect diminishes proportional to D^3. This formula is applicable only to spheres in which the size of the shortest α-ray is not exceeded by the diameter.

3. Varying proportions of hydrogen and oxygen changes the velocity as would be expected from the changes produced in the specific ionisations ($H_2 = 0·24$, $O_2 = 1·09$ referred to air $= 1$). Excess of oxygen gives a velocity higher than normal and which increases as the proportion of oxygen increases. Excess of hydrogen produces the opposite effect.

4. From No. 3 it follows that the emanation activates both of the pure components.

5. The temperature coefficient of the reaction between 0° and 25° is zero, as would be expected from ionisation.

6. Calculation of the ionisation by the method of average path of the α-particles shows that for each pair of ions produced in the gaseous mixture about 3·9 molecules of water are formed. (Scheuer found 3·7). Theoretical interpretation of this is deferred to the next paper.

7. Reaction in cylindrical volumes obeys the same law as in spherical ones, appearing to confirm the writer's earlier claim that the average path in the cylinder is the same as in sphere of equal volume.

The writer desires to thank Dr. R. B. Moore, Dr. Herman Schlundt, and Mr. J. E. Underwood for their advice and assistance in carrying out the foregoing experiments.

The Chinese Manganese Mines Association, 39, Szechuen Road, Shanghai, China, represents the three largest manganese mines in China, and wants information regarding markets in England for exporting the same. The analysis of the manganese ore from one of the mines is as follows :—Manganese, 52·52 (per cent); combined water, 3·82; iron, 3·90; silica, 5·14; sulphur, 0·049; phosphorus, 0·419: copper, 0·023. They also supply chemical manganese in powder or pea-sized form, of which the average manganese dioxide (MnO_2) is 75 to 80 per cent. They want to know the present prices in England of manganese ore, both for metallurgical and chemical uses, the standards and other conditions required by the buyers, the annual consumption, and the sources of their supply. They desire to be put into communication with principal consumers.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, June 26, 1919.

Sir J. J. Thomson, O.M., President, in the Chair.

The following papers were read :—

"*Monoclinic Double Selenates of the Cobalt Group.*" By A. E. H. Tutton, D.Sc., F.R.S.

This memoir deals with the four double selenates of the series $R_2M(SeO_4)_2.6H_2O$, in which M is cobalt and R is potassium, rubidium, cæsium, and ammonium. A complete crystallographic and physical investigation has been carried out on parallel lines to the work previously published concerning the magnesium, zinc, iron, and nickel groups, and to that concerning the completed analogous series of double sulphates. The results are in full accord with those derived from the previous investigations. It is an interesting fact that while each group of four salts containing the same M-metal and the four respective alkali bases presents its own absolute values for the various constants, and displays its own idiosyncrasies and individuality, yet the relations of the four salts to each other invariably exhibit the same regularities, gradations, and numerical progressions, even to the most apparently insignificant details, each group thus affording an independent confirmation of the truth of the general conclusions.

Two dominant facts emerge, namely, (1) the progressive order of all the crystallographic and physical properties, following the progression of the atomic numbers (and, therefore, atomic weights) of the interchangeable alkali metals concerned, potassium, rubidium, and cæsium ; and (2) the almost perpect isostructure—that is, congruency, coincidence, and equality of dimensions of the elementary cells of the monoclinic space-lattices—of the crystals of the ammonium and rubidium salts of the group. The progression with atomic number referred to under (1) is completely explained by the operation of Moseley's law, governing the progressive structural complexity of the atoms in accordance with the sequence of the atomic number.

"*A New Method of Driving off Poisonous Gases.*" By Hertha Ayrton.

"*Experiments with Perforated Electrodes on the Nature of the Discharge in Gases at Low Pressure.*" By F. W. Aston, D.Sc.

Experiments are described on the discharge between electrodes of a large flat form perforated with a long narrow slit, the charge passing through the slit being collected and measured in a Faraday cylinder.

Direct measurements made with the Faraday cylinder behind the cathode and at the same potential seem to indicate that about half the total current in the discharge is brought up to the cathode by positive ions.

Attempts to discover the distribution of velocities in this stream show that this is not directly determinable, owing to the very high ionisation in the region of the slit and other reasons, which are discussed.

Using a perforated anode, it is found that as the distance from the cathode is increased arithmetically the current carried by the cathode rays into the Faraday cylinder decreases geometrically when the current is constant.

The effect of (*a*) the distance apart of the electrodes and (*b*) the total current flowing, on the disappearance of the last trace of the positive column or Anode Glow is shown to be remarkably definite, but no adequate explanation of this phenomenon seems available at present.

"*De Saint-Venant Solution for the Flexure of Cantilevers of Cross-Section in the Form of Complete and Curtate Circular Sectors; and on the Influence of the Manner of Fixing the Built-in End of the Cantilever on its Deflection.*" By Mary Seegar and Prof. Karl Pearson, F.R.S.

"*Relation between Wind and the Distribution of Pressure.*" By H. JEFFREYS, D.Sc.

A classification of some 600 wind observations over the North Sea, according to their velocities and directions, showed that the most striking feature of the resulting values was their asymmetrical frequency distribution. From the fact that this was noticeable in nearly every class, it was inferred that it could be produced only by variation in turbulence or systematic contortion of the isobars, on a scale too small to be recorded on the weather map. The latter cause, however, and also such variations in turbulence as keep the coefficient of eddy viscosity the same at all heights, would lead to strong correlations between S/G and α, which are not observed. Hence, it is concluded that the principal cause of variation in the relation of the surface wind to the gradient is variation in the vertical distribution of turbulence; and it is shown that such variation could give the effects actually observed. To complete the test of the theory, it is necessary to have direct quantitative information on this distribution, which is not yet available; but the evidence already accumulated is sufficient to make it extremely probable that some information on the distribution, and hence on the lapse rate below 3000 feet, could be obtained by prediction from the observed relation between the surface wind and the geostrophic wind.

"*The Blood Vascular System of the Tuatara, Sphenodon punctatus.*" By Prof. C. H. O'DONOGHUE.

"*Fundamental Formulations of Electro-dynamics.*" By G. H. LIVENS.

The object aimed at in this paper is the removal of certain difficulties and discrepancies which exist in the usual formulations of electro-dynamic theory. After a brief statement of the differential theory in which a new equation—

$$\frac{dB}{dt} = \frac{dH}{dt} + 4\pi\frac{dI}{dt} + 4\pi \text{ Curl } [Iv]$$

is introduced to express the time rate of change of the magnetic force H when the magnetic media are in motion with a velocity v, a general formulation of the theory based on the principle of Least Action is developed in a manner which leads directly to expressions for the intrinsic energies of the polarised media, for the forces per unit volume on the polarised and charged media, and, finally, for the complete electromotive force on the moving electrical elements.

The general results derived are then examined in detail, and it is found that, except as regards the forces on the magnetic media, which is the subject of further analysis, the results are in general agreement with those previously formulated. The discrepancy in the latter case arises from the fact that the complete force on a moving magnetic pole is not H, as usually assumed, but $H - \frac{1}{c}[vE]$, in agreement with the relativity transformation.

The new expression for the complete force on the material media does not, however, lead to the usual concept of electro-magnetic momentum, the outstanding terms in the stress reduction not forming a complete differential; this, however, merely emphasises the auxiliary mathematical nature of the momentum idea.

"*Influence of Molecular Constitution and Temperature on Magnetic Susceptibility.* Part IV. *Further Applications of the Molecular Field.*" By A. E. OXLEY, D.Sc.

The main paper is a continuation of the work published in Royal Society *Transactions*, 1914, A, ccxiv., and 1915, A, ccxv., and Royal Society *Proceedings*, 1918, A, xcv. It deals with the following additional applications of the local molecular forcive in crystalline and vitreous media. The internal stress, which is a measure of the ultimate tensile strength of the medium, is found to be of the order 2×10^9 dynes per sq. cm., and the internal energy of the crystalline grouping of the order 2×10^9 ergs. per cc. This is in agreement to the order contemplated with the values of the heats of fusion of crystalline media and with their elastic constants. It is shown that the change of volume on crystallisation can be interpreted as a magneto striction effect of the molecular field. The molecular field is assumed to be proportional to the local intensity of magnetisation, the coefficient of proportionality being the reciprocal of the limiting susceptibility under field strengths equal to the respective molecular fields at different temperatures. A discussion of the nature of the molecular field is given, and the conclusion is reached that the forces of crystallisation are of a magnetic nature. The large value of the local magnetic forcive suggests that they may play an important part in chemical combination, and further evidence is given for the existence of the magneton in diamagnetic media. It appears that various anomalies of the Faraday effect may be interpreted in terms of the reverse action of the localised molecular field over rotationally active electrons.

"*Diffusion of Light by Rain, Cloud, or Fog.*" By A. MALLOCK, F.R.S.

In this note attention is directed to the similarity between the diffusion of light by small drops and the diffusion of heat by conduction. The drops under consideration are supposed to have, at least, diameters of many wave-lengths of the light scattered by them, so that peculiarities of diffusion dependent on the relation of diameter to wave-length do not affect the results. Rain, cloud, and fog are formed of such drops.

The opacity of a space containing a number of drops insufficient to completely obliterate objects on the far side depends on the lowering of the contrast between light and shade brought about by the light scattered by them, and not on any blurring or want of definition.

The amount of direct light which reaches the eye from a source within a fog or shower is proportional to 2^{-m}, where ml is the distance of the source from the eye, and l is the thickness of the stratum which reduces the direct light by one half. The reduction to one half will be caused by such a number of drops as would, if placed side by side in a plane to which the ray is normal, cut off all the direct light; but when the same number of drops are distributed at random in a volume of thickness l in the direction of the ray, they allow half the direct light to pass, in consequence of the probability that some of them screen others, and thus leave space for direct radiation.

A relation is shown between the rate of rainfall (1 inch per day = 1/86,000 inch per second) and the opacity of a shower.

CORRESPONDENCE.

ELEMENTS IN THE ORDER OF THEIR ATOMIC WEIGHTS.

To the Editor of the Chemical News.

SIR,—Some time ago ago I forwarded a letter in which I tabulated the chemical elements in the order of their atomic weights (CHEMICAL NEWS, 1918, cxvii., 339), the purpose being to illustrate the relationship between the elements as shown by the orderly increase in the weight of their atoms. Mr. F. H. Loring called my attention to the fact that similar schemes were in existence (CHEMICAL NEWS, 1918, cxvii., 352). Despite this I do not believe I have interpreted the scheme in the same light as by those mentioned in Mr. Loring's citations, although it cannot be denied the fundamental ideas are quite similar.

On noting the relationship I came to the conclusion that all elements originated from *two* primary substances having atomic weights of one and three, and upon condensation would combine to form, first, helium; and ultimately all of the elements with which we are familiar.

In working out a theory as to the origin of the elements the path is narrow, due to the lack of experimental evidence. Back in 1816, Prout drew practically the same conclusions as stated above except that he considered but one elementary substance—hydrogen. Either of the assumptions, however, can be used in conjunction with the Nebular Theory.

I, too, have assumed hydrogen with its atomic weight of one as a primary substance. As to the nature of the second, some speculation is necessary. It must be a gas to exist in a Nebula, and have an atom weighing three times that of hydrogen.

Sir J. J. Thomson, in his experiments with cathode rays, succeeded in producing a gas with an atomic weight of three. This would be an ideal gas to consider as the second true element. It has been designed as X_3, and "consists of three atoms of hydrogen and is represented by the formula H_3, bearing, in fact, the same relation to hydrogen that ozone does to oxygen."

If this is the gas sought, Prout's hypothesis still holds good as to hydrogen being the basis of all elements, as X_3, a triatomic hydrogen molecule, could then be considered the first product of condensation, and then upon its formation, immediately react with the original hydrogen to form helium and the remaining elements.

That condensation evidently takes place is shown by spectroscopically examining the stars. The hottest stars are of the hydrogen and helium type; another type, somewhat cooler, are known as the calcium stars, due to the calcium lines in their spectrum. Other, still cooler, show additional elements, but at no time can all elements present be determined, due to the fact that the spectroscope reveals information pertaining only to the outer envelope of the star.

In the examination of certain nebulæ, three prominent lines are found having wave-lengths of 4861, 4959, and 5007. The first is of the hydrogen series, while the last two, always appearing together and with the same intensity, represent an element which has been called "nebulium." The D_3 line of helium is also found in a nebula of this class.

If "nebulium" possessed a weight of three, this kind of nebula would serve as a practical example of my theory, as both primary substances are present as well as the first product of condensation in the form of helium.

In the phenomena of radio-activity it is known that when an element expels an alpha ray it is expelling helium atoms. Because of this we have reason to believe helium a common constituent of all elements (proof of such being possible to obtain only with those that are radio-active). We also know that the atomic weight of the product is lowered by four. This would naturally take place if the lighter elements had the power to expel helium atoms. Below I have listed the first 16 elements with the "theoretical" numbers assigned them in my previous letter. The reason for listing them as in the Periodic Table is to show that by lowering the atomic weight by four, the valency is lowered by two, as with the radio-active elements—

RH	RH_2	RH_3	RH_4	RH_3	RH_2	RH
R_2O	RO	R_2O_3	RO_2	R_2O_5	RO_3	R_2O_7

He 4	Li 7	Gl 8	B 11	C 12	N 15	O 16	F 19
Ne 20	Na 28	Mg 24	Al 27	Si 28	P 31	S 32	Cl 35

Examination of the tabulated table mentioned at the beginning of this letter will show that all of the elements do not coincide with the "theoretical" numbers as well as they might, the irregularity increasing as the weights increase. It is interesting to notice, however, that in most cases where the element does not coincide with the number assigned there is a blank space. Excellent examples are nitrogen at 15 and argon at 36.

In what appears to be the early stages of condensation, the elements were formed in keeping with the theory. As the weights increase irregularities develop. As mentioned above, they do not coincide with the theoretical numbers as well. The theoretical numbers cannot be applied to the Periodic Table in the same simple order as in the case of the first score of elements. Calcium is the last element to assume its proper place using the assigned whole number. The next element should be 43 and fall in Group III.; scandium, having a weight of 44, occupies this place.

It is possible that on condensing some elements may have combined with others, forming real compounds, but so bound together that they can only be analysed under conditions similar to those under which they were formed.

The fact that argon and potassium, as well as iodine and tellurium, have their places reversed in the Periodic Table almost proves that condensation has not been carried on perfectly. I might add that nickel and cobalt, having such similar properties as well as unusually close atomic weights, have never appealed to me as two clean-cut elements.

These remarks will, I trust, at least reveal another point of view in a matter which is as interesting as it is complex.—I am, &c.,

RAYMOND SZYMANOWITZ.

130, Sherman Avenue, Newark, N.J., U.S.A.,
July 8, 1919.

NOTES.

ROYAL INSTITUTION. — A General Meeting of the Members of the Royal Institution was held on July 7. The Special Thanks of the members were returned to Mr. A. B. Bence-Jones for his present of a crayon portrait by George Richmond of the late Dr. Bence-Jones, Secretary of the Royal Institution, 1860-73. Mr. A. M. Henryson Card and Dr. Edmonds were elected members.

SIR EVAN JONES, Bart., M.P., has found it necessary to resign his position as Commissioner of Dyes in consequence of the heavy duties attaching to the post of Controller of the Coal Mines Department. In future, therefore, all communications referring to dyes should be addressed to the Assistant Secretary, Industries and Manufactures Department, Board of Trade, Gwydyr House, Whitehall, London, S.W. 1.

LIVINGSTONE COLLEGE.—Dr. T. Jays, whose work with the Church Missionary Society and the Student Christian Movement is well known, has accepted the post of Vice-Principal of Livingstone College, where the session will recommence on October 1. Dr. Jays and his wife will be resident in the College, and in addition to helping the Principal, Dr. Wigram, in other ways, will take the lectures previously delivered by Col. G. B. Price. The latter has gained the well-merited honour of C.M.G. for his work in Malta during the war, and is now taking up important work under the Ministry of Pensions to organise and advise on the treatment of discharged soldiers suffering from tropical diseases. It is in consequence of this that he can no longer continue his lectures at Livingstone College, which have been very much appreciated by the students of the thirteen sessions during which he has worked there. Before the college reopens on October 1 a short course of fifteen lectures on "Personal Care of Health in the Tropics" will be given from September 22—25. Col. Price hopes to be able to take some of these lectures, the others will be given by the Principal and Vice-Principal. These lectures are open to men and women, and are intended for those who expect to reside in the Tropics. They would be of use to missionaries, nurses, explorers, members of the services, Government officials, commercial men, &c. The fee for the whole course is 30s., or 3s. for a single lecture. Application should be made previous to the lectures to the Principal, Livingstone College, Leyton, E. 10,

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Chemist required to assist in carrying out Scientific and Technical Research Work. Candidates should preferably hold a University degree or its equivalent, and have had some previous experience in conducting independent investigations.—Write, stating qualifications, age, and salary required, to "M. R. C.," care of Street's, 30, Cornhill, E.C. 3.

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THE CHEMICAL NEWS

VOL. CXIX., No. 3095.

ON THE
PHOTOGRAPHIC SPECTRA OF METEORITES.*

By Sir WILLIAM CROOKES, O.M., F.R.S., LL.D., &c.

(Concluded from p. 55).

GNARENBURG (from Hanover, Prussia). The photographed spectrum of this aerolite extends from λ 2714 to 5896, and includes in addition to the lines of iron 2 aluminium, 3 calcium, 31 chromium, magnesium, 3 manganese, 50 nickel, 2 potassium, 6 sodium.

Hvittis (from Abo, Finland). The photographed spectrum of this aerolite commences at λ 2852 and extends to 5896; it includes in addition to the lines of iron 1 calcium, 30 chromium, 3 magnesium, 3 manganese, 31 nickel, 4 sodium.

Jelica (from Servia). The photographed spectrum of this aerolite commences at λ 2852 and extends to 5896, and includes in addition to the lines of iron 1 calcium, 29 chromium, 3 magnesium, 3 manganese, 34 nickel, 2 potassium, 4 sodium.

Jhung (from Punjab, India). The lines shown in the photographed spectra extend from λ 2883 to 5896, and include in addition to the lines of iron 2 aluminium, 2 calcium, 22 chromium, 3 magnesium, 3 manganese, 43 nickel, 2 potassium, 6 sodium.

Kansada (from Ness County, Kansas, U.S.A.). The photographed spectrum of this aerolite commences at λ 2852 and extends to 4652, and includes in addition to the lines of iron 1 calcium, 26 chromium, 1 magnesium, 3 manganese, 45 nickel, 4 sodium.

Khairpur (from India). The photographed spectrum of this aerolite commences at λ 2852 and ends at 5896, and includes in addition to the lines of iron 2 aluminium, 3 calcium, 29 chromium, 4 magnesium, 3 manganese, 41 nickel, 2 potassium, 6 sodium.

Launton (from Bicester, Oxfordshire). The whole of the 5 grm. of material available quickly burnt out and only short exposures were possible. The photographed spectrum extended from λ 3302 to 5896, and includes in addition to the lines of iron 2 aluminium, 2 calcium, 21 chromium, 2 magnesium, 3 manganese, 20 nickel, 2 potassium, 6 sodium.

Mount Brown (from Evelyn County, New South Wales). The photographed spectrum of this aerolite extends from λ 2599 to 6643, and includes in addition to the lines of iron 3 aluminium, 3 calcium, 28 chromium, 11 magnesium, 3 manganese, 55 nickel, 6 sodium.

Mount Dyrring (from Durham County, New South Wales). The lines found in the photographed spectrum of this aerolite extends from λ 2482 to 4652, and includes in addition to the lines of iron 25 chromium, 17 magnesium, 3 manganese, nickel, 2 potassium, 6 silicon, 2 sodium.

Nammianthal (from South Arcot, Madras, India). The photographed spectrum of this aerolite extends from λ 2716 to 4652, and includes in addition to the lines of iron 2 calcium, 23 chromium, 3 magnesium, 3 manganese, 50 nickel, 2 sodium.

Parnellee (from Madras, India). The photographed spectrum extends from λ 2788 to 5896, and includes in addition to the lines of iron 1 aluminium, 24 chromium, 3 magnesium, 3 manganese, 50 nickel, 2 potassium, 6 sodium.

Before discussing in detail the composition of these aerolites as revealed by their arc spectra it is well to record one or two points of general importance. Keeping the current and voltage constant, the number of lines recorded in the arc spectrum of a compound substance depends in large measure upon the time-length of the "exposure" and the sensitiveness of the photographic plate. For instance, if in an exposure of say five minutes there are a mass of lines, having some that are very much over-exposed and some that are only just visible, by making another exposure of the same material for double the time the very faint lines would appear stronger, and others that in the shorter exposure were not visible would come into view, and so on. But in practice a limit is fixed, governed partly by the demands of the strong lines and partly by the amount of the material at one's disposal. This latter limitation, the amount of material available, is very potent when dealing with such substances as rare meteoric stones.

From an examination of the whole set of aerolite spectra it appears that the proportion of nickel to iron is generally constant. There is a nickel line at λ 3619·391 and an iron at 3618·919; these two lines form a close pair, and in twenty-seven out of the thirty spectra they remain in the same relative intensity, being faint or strong according to the general character of the spectrum. But in three, Bustee, El Nakhla, and Aubres, while the iron line shows as usual, the nickel line is either absent altogether or very faint. (In connection with this proportionality between the lines of iron and nickel, I have examined the spectra of a number of siderites, and in the majority of instances the proportionality remains constant; but there are a few cases in which the nickel line is fainter than that of iron and others in which it is stronger).

In several of the aerolites in my list it will be seen that the total number of lines recorded is below the average. The aerolite Bustee is an instance. (Through the kindness of the Trustees of the British Museum and of Dr. Prior, three successive portions of this aerolite, making 12·171 grm. in all, were placed at my disposal). The rapidity with which it burnt away in the arc prevented me from giving the length of time for each exposure necessary to bring out many of the fainter lines. A rather interesting point came out in connection with this aerolite.

In the early work my stock of material amounted only to about 2 grm.—and the length of time given for an exposure was necessarily short—it was noticed that although the stronger chromium lines came out in good intensity, the nickel lines were absent. Having obtained more material I was able to get photographs with longer exposures; the nickel lines could then be seen, although as a whole much more faintly than those due to chromium. This gave rise to some experiments upon the relative photographic intensity of the two metals under the conditions in which I was working.

The chromium spectrum is fairly rich in lines. Under the conditions prevailing in these experiments, in addition to a large number of faint lines there are recorded about one hundred strong ones, and of these there are three groups, which might be called the dominant lines of the elements; the strongest of these groups is composed of the three lines at λ 4254·50, λ 4274·97, and λ 4289·90; the next strong group is also three lines at λ 3578·840, λ 3593·633, and λ 3605·478, and the faintest consists of two lines, λ 4862·02 and λ 4870·9.

Some pure chromium was taken and reduced to powder, some pure electrolytic nickel was prepared in the same way, and a mixture was made of silver, kaolin, and yttria, with 10 per cent each of Ni and Cr. This was pressed into a button and the spectrum taken as in the case of the aerolite. It was at once seen that the chromium groups came out in greater intensity than the adjacent nickel lines.

The mixture above referred to is the outcome of many experiments made to find a material capable of carrying small percentages of nickel and chromium, so that when

* Read before the Royal Society Nov. 2, 1916. From the *Philosophical Transactions of the Royal Society*, A ccvii., 411.

mixed with silver and formed into electrodes for the arc it should behave in a way similar to an aerolite; the yttria was only used as a diluent of known composition. (Incidentally, I may say that this is a very convenient method for obtaining the arc spectra of the rare earths).

An extensive series of experiments were carried out to throw light upon the photographic effect of known percentages of chromium under the conditions obtaining in the aerolite spectra.

Two electrodes were made as follows :—

Yt_2O_3	70
Kaolin	10
Nickel	15
Chromium	5
	100

And to this was added an equal weight of pure silver powder. The arc spectrum was then photographed under conditions similar to those of the aerolites.

It was seen that the chromium groups were still the most prominent lines in the spectrum, those of nickel being comparatively faint.

Keeping the other ingredients constant and gradually reducing the proportion of chromium several more experiments were made, and it was found that when the chromium had been so reduced that it was only 0·16 per cent, the lines λ 4862·02 and λ 4870 9 were no longer visible; a further experiment with electrodes containing only 0·1 per cent chromium distinctly showed the other two groups.

These experiments show that it is easy to detect the presence of chromium in an arc between electrodes that contain only 5 parts Cr in 10,000.

It is not easy to see why in subjecting the two elements nickel and chromium to the heat of the electric arc it should produce so much more intense atomic disturbance in one case than in the other—the melting-points of the two elements are not very different—it may be, however, that the volatilisation points differ. I have pursed this matter in connection with the examination of a large number of meteoric irons (siderites) that will form the subject of a further communication.

(Without anticipating this communication on siderites, I desire to point out the remarkable fact that although the chromium lines appear, sometimes very strongly, in all my aerolite spectra they do not appear in any of the siderites I have so far examined—except in one instance, that of "Zacatecas." Although of course the nickel lines are always visible—from the spectroscopic examination of a number of specimens of iron, to which I had added decreasing amounts of chromium, I found that the dominant lines of chromium were quite visible even when the amount present was no more than 0·0175 per cent. This is due to the fact that chromium is absent from the nickel-irons but almost universally present in the aerolites in the form of chromite. In Aubres, &c., there is probably more chromite than nickel-iron. In the magma which produced meteorites all the Cr was converted into oxide or sulphide, giving rise to the mineral chromite or daubreelite and leaving no Cr for the nickel-iron).

Although these experiments only make it possible to form an approximate estimate of the amount of chromium present in these aerolites it would seem to lie between 0·6 per cent and 0·1 per cent.

In the previous experiments the proportion of nickel which was kept the same in all mixtures was evidently in considerable excess of that contained in any of the aerolites; the experiments were therefore continued, blocks made in the same way as in the experiments with chromium were used as electrodes for the arc. The proportion of nickel was from 2 per cent down to 0·04 per cent—photographs of the spectrum were made under the usual working conditions. The portion of the spectrum taken was that containing the chromium group, λ 3578·840, λ 3593 633, λ 3605 478, and the closely adjacent nickel lines; it was found that when the amount of nickel was reduced to 0·04 per cent the line 3619·391 was only just visible.

The information gained from these mixtures of chromium and of nickel made it possible to obtain an approximate estimate of the quantities of these elements present in the three aerolites, El Nakhla, Aubres, and Bustee. A mixture containing chromium 0·25 per cent and nickel 0 04 per cent gave a photograph which for Cr-Ni was practically identical with that of Aubres.

The estimation made in this way cannot be more than a "good approximation" on account of unavoidable variations, due to intensity of light and time of exposure; also to conditions of photographic development, which cannot be *exactly* controlled, but the indications given by the relative intensities of closely adjacent Ni and Cr lines when they occur on the same film are very much more exact, and the result proves that in these aerolites the element chromium exists in greater abundance than nickel.

To this fact must be added that of the almost total absence of chromium in the familiar nickeliferous irons of the siderites.

In a general survey of the spectrum analyses of the 30 aerolites which forms the subject of this paper, the most striking fact, is their similarity in composition, and the small number of elements represented. Making full allowance for wide differences in the photographic activity of the arc spectra of the elements, it is remarkable that we only see with certainty the lines due to some *ten* bodies, and of these ten, four only—iron, chromium, magnesium, and nickel—appear to be present in quantity. With three exceptions, Bustee, El Nakhla, and Aubres, the proportion between these elements appears to be practically the same in all.

This suggests that these earthy meteorites must have a common origin, and that origin might be due to the disruption of a body in which the process of cosmial evolution has been completed; in short, may we not conclude that the aerolites are fragments of a finished and cooled planet. It is possible that we have in our museums fragments of a world unrealised—a world that at one time had its place between Jupiter and Mars in our planetary system.

From the results of my unfinished notes on the spectrum analyses of meteoric irons, to which I have already referred, it would appear that either the siderites are of a different origin, or that they have constituted the solid nucleus or core, from which by some process at present unknown the chromium and other elements had been separated, leaving the magnetic elements iron and nickel as the familiar ferro-nickel meteorites.

IS THE ELECTRICAL CONDUCTIVITY OF THE ELEMENTS CONDITIONED BY THE PRESENCE OF ISOTOPES?

A Supplementary Note.*

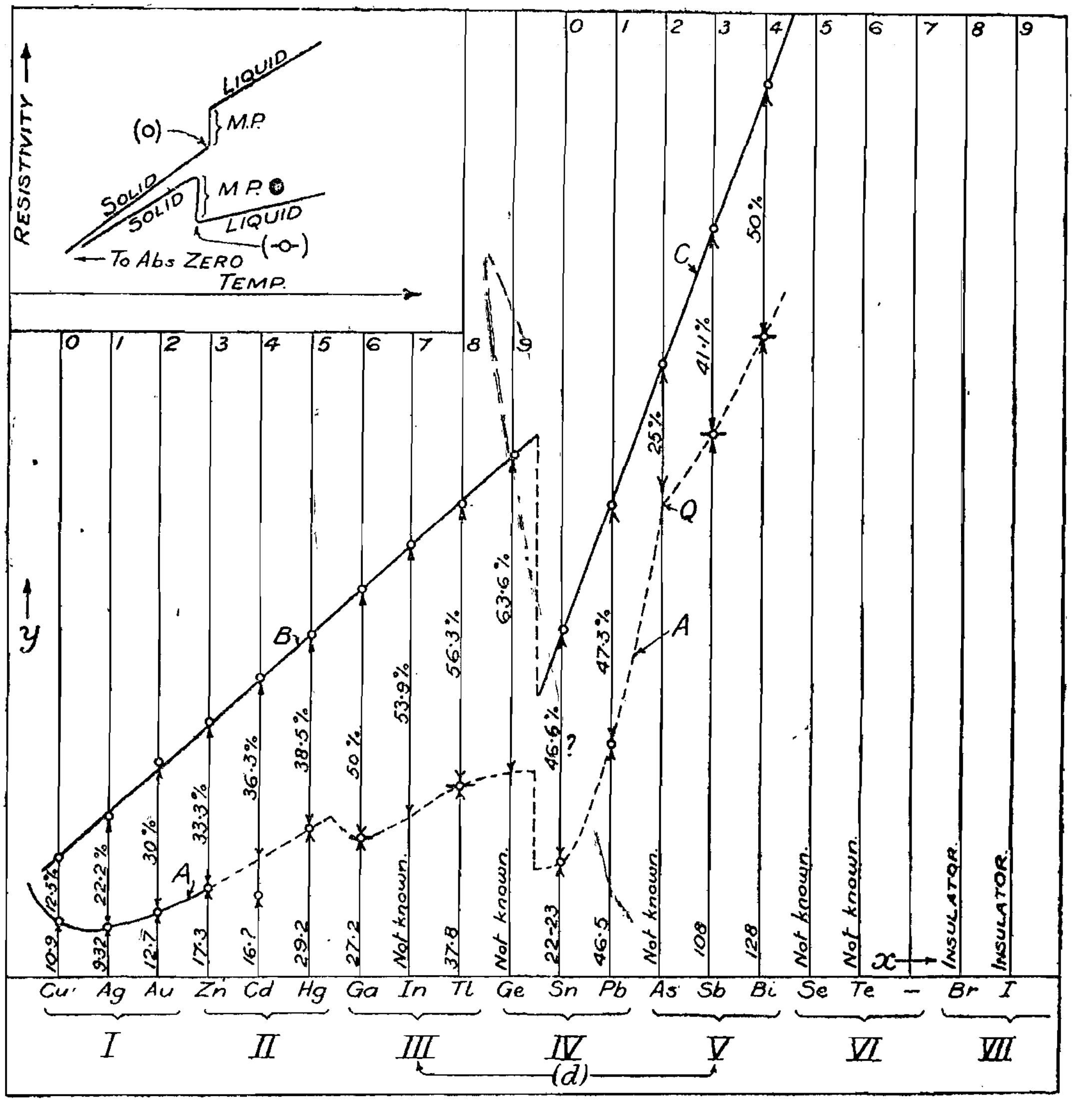
By F. H. LORING.

If the percentages of isotopes, which were given in my previous paper, be plotted additively with the resistivities, also given, a straight-line curve is obtained, showing a relation which seems to imply that the theory of whole-number isotopes as applied to the ordinary elements is not without some foundation of fact. The accompanying diagram shows the relation.

Commenting on the diagram, cadmium is an exception in not fitting in with the percentage rule suggested, but as there is a peculiarity in Northrup's temperature-resistance

* To be read in conjunction with my paper in the Chemical News, July 11, 1919, cxix., 14.

curves for zinc and cadmium, and the curve of the former is not confirmed by Tsutsumi, the value for cadmium may be queried. Should, however, the abnormal characteristic of cadmium eventually be established, then a closer study of the exception might prove of interest. Gallium contracts on melting, and the resistance of this element in the state of maximum density close to the melting-point is $27{\cdot}2 \times 10^{-6}$ (A. Guntz and W. Broniewski, *Comptes Rendus*, cxlvii., 1474). Plotting 50 per cent—which is the most regular value involving an isotopic proportion of continuity to the curves B and C. The choice of resistivity is, however, in accord with the principle of nearest state, since there is likely to be nearer comparableness if the values be taken when the elements are in their most dense state at fusion. The example of gallium given above makes this point clear. The plotted values for the resistivities of cadmium, tin, and lead are those of Northrup (*loc. cit.*, previous paper). Tsutsumi's values for tin and lead are respectively 23·8 and 48·1. There is therefore little to choose between the values of these investigators. The



5 to 5 as given in the CHEMICAL NEWS (1914, cx., 25)—on the foregoing value gives one that falls exactly on the straight-line curve B. The resistivity of thallium at fusion is obtained from Vincentini and Omodei's paper (*Atti. Accd. Torino*, 1889-90, xxiii., 30), but these investigators give no series of values which can be plotted, so that some uncertainty obtains with regard to the use of the *single* value calculated from the data given.

It will be seen that in those cases in which the —o— values are taken (see inset diagram) the percentages for the lower-mass isotopes are selected in order to give value for arsenic at Q is, perhaps, what one might expect as obtained under suitable conditions necessary to impart to this element the proper state for comparison if this be possible.

The relation plotted can be expressed mathematically thus:—

Let x_1 = periodic place, as shown in the diagram, numbered 0, 1, 2, &c., up to 9; for Cu, Ag, Au, Zn, Cd, Hg, Ga, In, Tl, and Ge.

Let x_2 = periodic place, numbered 0, 1, 2, &c., starting at tin = 0; for Sn, Pb, As, Sb, Bi, &c.

Let r = the specific resistance or resistivity at the melting-point when the density of the element is the greatest. The 10^{-6} multiplier may be neglected in these calculations.

Let p_1 = the percentage of higher-mass isotopes for the (o) resistivities, or the percentage of lower-mass isotopes for the (—o—) resistivities (see inset diagram).

Then—

$$23 \cdot 3 + 9x_1 = y_1 = p_1 + r,$$

this equation being for the elements from copper to germanium inclusive, as shown in the diagram, and—

$$3 \times 23 \cdot 3 + 3 \times 9x_2 = y_2 = p_1 + r,$$

this equation being for the elements from tin to bismuth inclusive, no attempt being made to extrapolate beyond bismuth.

The original plotting is such that one group-place = 10 mm., and the percentage and resistivity values are on the scale 1 mm. = one whole number.

Groups III. and V. are joined by a line (*d*) to indicate that possibly all the elements of these two groups contract more or less on passing from the solid to the liquid state, as is known to be the case with gallium, antimony, and bismuth.

Referring to the Chemical News (1915, cxi., 13), the isotopic proportions for gallium, indium, tin, and lead should be taken respectively, 5 and 5, 7 and 6, 7 and 8, 10 and 9, to have percentages in agreement with the rule herein given, and when this is done the isotopic proportions, or "atom-numbers" as originally termed, form a regular numerical set of sequences throughout the section of the periodic table under consideration, but in the case of tin the lower atomic mass percentage (46·6) fits on the straight-line curve when plotted from the resistivity value 23. This may represent a wrong procedure, as it would seem to imply that tin was similar to antimony and bismuth, whereas it resembles lead in its resistivity characteristics. The higher percentage, 53·3, is perhaps the correct one to use, and when a better measurement is made of tin this point can be reconsidered. The resistivity, to agree with the higher percentage, should be about 17. The lowest experimental value is about 21. It should be noted that the above numbers which appear to require a revision on account of the new relation, were queried in the above communication. All the other isotopic-proportion numbers herein used are the same as originally given.

The theory of conduction is of possible interest in connection with the apparent atomic relationships shown, for consider a small-mass nucleus so close to a large-mass nucleus that the electronic orbits combine (or nearly combine) to form a figure eight, the electrons tending to leave the former to pass round the latter owing to the greater attraction of the larger mass. Overloading the circuit electrically at any point might then give rise to a progressive flow of electrons from atom to atom. On cooling the metal, a point might be reached when further cooling (contraction) would not improve the contiguity of the orbits, so that perfect conductivity of electricity without any oscillation or vibration of the atoms (heat or C^2R loss) might take place at a temperature just above absolute zero.

NOTE ON ALUMINIUM AND A DOUBLE SALT.

By E. RATTENBURY HODGES.

In "Watts' Dictionary" (Second Edition, 1890) it is stated at p. 142, col. 2, that "concentrated or dilute nitric acid has no action on Al." This appears to be incorrect. "The time—element" must in this, as in other cases, be taken into account. After exposing Al foil to the action of the slightly diluted acid for seven or eight weeks I found that nearly all the metal dissolved, to form, not a definite salt, but after slow evaporation, a light grey and somewhat colloidal mass with some free acid in it.

The strength of the original acid may be a factor in this case. On raising the cover at infrequent intervals during the reaction, a faint odour of nitrogen peroxide was noted. The resulting solid is partly if not wholly aluminium hydrate, as it failed to deflagrate.

So far, it seems that nitric acid does not combine with the metal to form a normal salt, but slowly converts it into a hydrate.

As to double salts, it is to be regretted that references to them are so few, far between, and even meagre (to judge from common text-books); moreover, *e.g.*, in Watts, vol. i., p. 146, col. 2, we get no more than this:—"Very many Al salts also form double salts; the most characteristic of which are the alums," and 22 lines at p. 426, vol. iv. A double chloride of Fe and Al recently rewarded the writer's efforts. It took the form of tabular crystals, about 3 mm. square, of a delicate apple-green and was somewhat deliquescent as damp weather approached.

Addendum.—Since the above was written, this salt has proved unstable. With a further slight increase in general humidity the salt has broken down, the solid remaining being mostly ferric oxide.

Obviously the formula of this double salt, its water of crystallisation, and refractive index, &c., have yet to be determined.

CHEMICAL ACTION PRODUCED BY RADIUM EMANATION. II.*

The Chemical Effect of Recoil Atoms.

By S. C. LIND.

1. *Introduction.*

In Part I., the preceding paper, it was shown that the velocity of combination of hydrogen and oxygen gases at ordinary temperature, under the influence of radium emanation mixed with them, can be conveniently measured by following the reduction in pressure at constant volume. An apparatus suitable for this purpose was described, and data were given proving the applicability of a kinetic equation based on the assumption that in a given limited volume the reaction velocity is proportional to the amount of emanation E present at any time and the gas pressure P, both variables, the latter varying as a function of the former.

The change of pressure produced is also dependent on the volume of the containing vessel as well as on the quantity of emanation. In small vessels, say a sphere of 1 cm. diameter, owing to the limited quantity of gas, the pressure falls very rapidly (unless the quantity of emanation be extremely small), so that a condition is soon reached in which the layer of gas traversed by an α-particle becomes very thin, the order of a few mm. Of course, the same condition can be attained in larger chambers, but is not reached, starting from normal pressure, without much larger quantities of emanation, owing to the greater volume of gases to be acted on before the pressure sinks to low values.

On attempting to apply the same kinetic equation to the velocity observed in a 1 cm. sphere, as had been found applicable for larger spheres, no constant was obtained but a value which rose rapidly as the pressure diminished. This puzzling discovery could not be explained by the action of α-rays alone, but an analysis of the results suggested that it could be explained on the assumption that the "recoil atoms" produce chemical action proportional to their ionisation, just as the α-particles do.

It may be profitable to consider briefly something of the properties of "recoil atoms." When an atom, like Ra A or Ra C, emits an α-particle, the residual atom recoils with

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a velocity that may be calculated from the principle of conservation of momentum to be about 1/50 of the velocity of the α-particle emitted (Rutherford, "Radio-active Substances and their Radiations," 1913, p. 174). This velocity and corresponding kinetic energy is sufficient to impart to the "recoil atoms" ionising properties through a limited range, which range is increased by reducing the pressure or density of the gaseous medium. "Recoil atoms" were first studied by Miss Brookes (*Nature*, July 21, 1904), by Hahn (*Verh. Deut. Physik. Ges.*, 1909, xi., 55), and by Russ and Makower (*Proc. Roy. Soc.*, 1909, A, lxxxii., 205) as a method of separating the "recoil atom" in a pure state. More recently the most complete investigation of "recoil atoms" hitherto undertaken has been made in the laboratory of Mdme. Curie by L. Wertenstein ("Thesis," 1913, Gauthier-Villars, Paris, Publishers), to whose careful study we are indebted for most of our present knowledge of the subject.

The "recoil atoms" from the disintegration of Ra A have been called α-particles. Wertenstein has found they have a range in air at atmospheric pressure of 0·14 mm., and in hydrogen of 0·83 mm. This range in air is about 1/350 of the range of an α-particle of Ra A, and since the kinetic energy of the α-particle is 1/50 of that of the corresponding α-particle it is evident that the expenditure of energy by the α-particle must be about seven times greater per length of path than that of the α-particle. This does not mean that the resulting ionisation is seven times as great, because the proportion of energy producing ionisation is somewhat smaller in the case of α-particles, but Wertenstein finds that the ionisation produced by α-particles becomes in maximum about five times greater than that of α-particles over the same path.

This knowledge of "recoil atoms" suffices at least for a preliminary survey of what might be expected of "recoil atoms," if they produce chemical action in proportion to their ionising power, as α-particles do. The two factors to be kept in view are the very limited range of recoil atoms and their greater intensity of action within their limit.

Beginning in a volume and at a gas pressure at which the α-particle would have a sufficiently long path to expend a considerable fraction of its kinetic energy before striking the wall, the comparative effect of the recoil atom would be too small to be detected. On reducing the volume or pressure the effect of the recoil atom remains constant, while that of the α-particle is diminished by the shortened effective path. Therefore the effect of the recoil atom becomes relatively more and more prominent, and would reach a maximum when the pressure reaches the value at which the ionising power of the recoil atoms would become practically constant along the path, which is the case very near its origin. If the chemical action under this condition were proportional to the ionisation the chemical effect of the recoil atoms would be about five times that of the α-particles, or the total velocity would be six times the normal, due to α-particles alone.

With this preliminary analysis made one is ready to proceed to the examination of the experimental data, to ascertain if they indicate the truth of the assumptions. Later, the more quantitative aspects can be considered.

2. *Experiments.*

The experimental procedure and apparatus are the same as described in Part I., the foregoing paper, for the combination of hydrogen and oxygen by radium emanation. An electrolytic mixture of hydrogen and oxygen was employed mixed with radium emanation in a small spherical reaction bulb.

In Table I. will be found the experimental data as well as the interpolated data and calculated results. $k\mu/\lambda$ and $(k\mu/\lambda)'$ are from Equations 1 and 2, respectively, of Part I., and have the same signification as velocity of reaction constants, or better, *factors* since they are not constant.

Cols. 1 and 2 give the actual results of the measurements. In Col. 3 the values of $k\mu/\lambda$ illustrate the marked increase in the velocity. Evidently the constant should be calculated from measurement to measurement instead of from the beginning each time. This has been done in Col. 4, where $(k\mu/\lambda)'$ brings out the increase more clearly. But even yet the intervals are rather large. Therefore a curve has been plotted (Curve 1, Fig. 1) from the original data of Table I., from which the interpolated values of Col. 6 were taken. $(k\mu/\lambda)'$ calculated from the interpolated data brings out the rise very distinctly. (The figure will appear in our next issue).

TABLE I.—*Effect of Recoil Atoms in producing the Combination of Hydrogen and Oxygen at Ordinary Temperature in Small Volume.*

Vol. = 0·470 cc. Exact diam. = 0·9647 cm. E_0 = 0·04234 curies.

Actual data. Time.		P.	Calculated from actual data.	
Days.	Hours.	Mm. Hg.	$k\mu/\lambda$.	$(k\mu/\lambda)'$.
0	0	507·8	—	—
0	15·67	310·3	104·6	104·6
0	19·90	271·2	105 9	111·2
0	23 67	235·1	111·4	142·9
1	15·33	135·4	121·4	139·0
1	19·00	119·0	123·4	148·7
2	5·00	76·7	134·8	195·0
3	0·33	18·8	181·3	349·6
3	15·42	5·0	220·5	483·3

Time.		Interpolated data.	
Days.	Hours.	P.	$(k\mu/\lambda)'$.
0	0	507·8	—
0	6	425·0	95·6
0	12	354·0	102·7
0	18	290·0	117·1
1	0	233·0	134·4
1	6	187·0	141·6
1	12	150·7	145·0
1	18	123·0	148·8
2	0	96·0	182·4
2	6	73·0	210·9
2	12	51·5	278·9
2	18	33·0	377·6
3	0	19·5	461·7
3	3	14·0	594·3
3	6	9·9	646·0
3	9	7·5	528·5
3	12	5·7	535·1
3	15·42	5·0	228·3

In Fig. 1, Curve 1 shows the actual course of the reaction. Curve 1 A shows the course the reaction would have under the normal action of α-particles, calculating the pressure from the equation—

$$k\mu/\lambda = \log (P/P_0)/(E_0(e^{-\lambda t} - 1)),$$

and taking $k\mu/\lambda$ = 90·4 from the general relation $k\mu/\lambda$ = 84·1/D^2 (Part I., Section 5). Curve 2 in Fig. 1 represents by (–) the values of $(k\mu/\lambda)'$ from the last column of Table I. It illustrates how the reaction velocity at high pressures has a normal value, rises slowly at first, and then very rapidly as the pressure drops. (In using Curve 2, Fig. 1, it is to be kept in mind that the abscissæ do not refer directly to pressure but to time. The corresponding values of pressure must be obtained through reference to Curve 1, or from Table II.). After passage of the maximum the value drops off almost perpendicularly, owing to practical exhaustion of the reaction gases. It may be remarked that for obvious reasons very pure electrolytic gas is required to avoid disturbances toward the end of the reaction.

The points marked + along Curve 2 are those required by the theory to be discussed shortly; near the intersection

with Curve 1 they are marked (+) to distinguish from the points of Curve 1.

3. *Quantitative Consideration of the Results.*

Having shown in a general way (Section 1) that the marked rise in the velocity constant $k\mu/\lambda$, as illustrated in Fig. 1 (Curve 2) from the data of Table I., might be accounted for by the chemical effect of the recoil atoms, adding itself to the normal chemical effect of the α-particles it remains to study the quantitative aspects to see if the theory seems to fit the facts.

The normal value of the velocity constant for the action of α particles alone upon hydrogen and oxygen would be, in a bulb of the size used (Table I.), 90·4. Twice this velocity, or 180·8, would be attained under conditions at which the chemical effect of the recoil atoms just becomes equal to that of the α-particles. As can be found from the curves of Fig. 1 this would be reached at a gaseous pressure of 118 mm. At any other pressure the proportion of chemical action being produced by each type of radiation could be estimated on the following basis:—

1. That the total effect of the recoil atoms remains constant down to the pressure at which they also reach the wall before completing their paths.

2. That the total effect of the α-particle will at all pressures be proportional to the pressure. For example, at the pressure of 118 mm. the two effects are equal, and one can arbitrarily place each equal to 118. At any other pressure, 50 mm. for example, the recoil atom effect, which for convenience will be called the a effect (see Note), would still have the value 118; the α-effect will have the value 50; the combined effect will be 168, and the ratio of abnormal to normal effect will be $(a+\alpha)/\alpha = 168/50 = 3·36$. Table II. shows this same calculation carried to its upper and lower limits.

(Note.—In using the term a-particle for the recoil atoms of radium emanation it is to be remembered that it properly refers only to recoil atoms from Ra A, but here it will be used to include also those from emanation and Ra C. The recoil atoms from the β-rays have so little energy that they can be entirely neglected).

By comparison of the last two columns of Table II. the general trend of the calculated and experimental values of $(k\mu/\lambda)'$ can be seen to be the same. The calculated values have been put in Fig. 1 as +, and show a satisfactory agreement between the theory and the experimental data. The maximum value found, 632, when divided by the normal α-value 90·4, shows that the maximum ratio $(a+\alpha)/\alpha$ becomes 6·99. According to Wertenstein the maximum ionisation due to a-particles is five times that of the α-particles over the same path, which would mean a factor of six times the α-effect alone. Remembering that Wertenstein's statement refers to recoil atoms of Ra A alone, it will be seen that the agreement for all three sets of recoil atoms between ionisation prediction and chemical effect is perhaps as good as could be expected.

At first sight it may appear surprising that the chemical effect of the recoil atom can be observed at fairly large pressures. One must consider, however, that the radius of the reaction bulb is 4·8 mm., and that the average path within the bulb is only 7/10 of this, or about 3·3 mm., and, moreover, the range of the a-particle in the electrolytic mixture will be about 0·30 mm. at standard pressure (calculated from Wertenstein's values for hydrogen and air), and would be still greater for the recoil atom of Ra C. These facts, considered together with the intensity of the energy expense by recoil atoms, make it evident that the pressure and bulb dimensions at which the effect manifests itself are quite concordant with Wertenstein's ionisation data.

Finally, it should be inquired whether the effect of recoil atoms will not also be manifested in larger bulbs at low pressures. The answer must be affirmative with certain reservations. Referring to Table I. of Part I., it can be seen for the 2 cm. and 3 cm. bulbs that there is an unmistakable tendency for the velocity constant $k\mu/\lambda$ to increase slightly toward the end of the reaction, which tendency would be brought out more distinctly by calculating for $(k\mu/\lambda)'$. As already explained, however, the quantity of gas to be acted on in the larger bulbs is so much greater that before low pressures are attained the emanation is nearly exhausted and the effect on the values of $k\mu/\lambda$ is largely masked.

Table II.

α-Effect = const. = 118. α-Effect = pressure (P).
Calculated $k\mu/\lambda = 90·4 \times (\alpha+a)/\alpha$. $(k\mu/\lambda)'$ (found) from Table I.

P.	$a+\alpha$.	$(\alpha+a)/\alpha$.	$(k\mu/\lambda)'$ calc.	$(k\mu/\lambda)'$ found.
10	128	(12 80)	—	—
20	138	6 90	622	632
30	148	4·93	444	446
40	158	3·95	356	376
50	168	3 36	303	330
60	178	2 97	268	292
70	188	2 69	242	267
80	198	2·48	223	240
90	208	2·31	208	223
100	218	2·18	195	204
110	228	2·07	186	192
120	238	1·98	177	182
130	248	1·91	172	166
140	258	1·84	166	162
150	268	1·79	161	153
200	318	1·59	143	133
250	368	1·47	132	118
300	418	1·39	125	112
400	518	1·29	116	100
500	618	1·24	113	85
600	718	1·19	107	—

4. *Summary.*

The results of the foregoing experiments may be summarised as follows:—

1. The action of radium emanation in causing the combination of electrolytic hydrogen and oxygen is abnormally high in small volume, particularly at low gas pressure.

2. Application of a suitable kinetic equation shows that in maximum the velocity becomes six or seven times greater than that due to the normal α-ray effect.

3. It is shown that this can be explained by the assumption that the recoil atoms contribute to the reaction in proportion to their relative ionising power.

4. The results appear to be in general agreement with Wertenstein's ionisation data for recoil atoms.

(To be continued).

THE DIFFUSION OF DOUBLE SALTS.

By D. Merrill Torrance

A. *Antimony Potassium Tartrate*—

CH(OH)COOK
|
CH(OH)COOSbO.

If the atoms are all the same size while differing in weight, the impact on the walls of the porous partition would be greater by the atom having the greater weight. On the other hand, if the atom "hydrates" in the solvent and thereby the size is increased, such atoms would diffuse more slowly through the porous cup.

We used a porous cup made of parchment, of 50 cc. capacity, using 40 cc. each time, and made tests of different concentrations of the salts, varying the time and the temperature. We made the tests in duplicates, using the same kind of porous cups as nearly as we could determine. The antimony and potassium were determined by the usual methods.

1. 5 per cent solution. Six hours at room temperature.

	No. 1 dialyser.	No. 2 dialyser.
Sb	0·1408 grm.	0·1395 grm.
K	0·1075 „	0·0924 „

According to the atomic weights, the antimony should pass through the dialyser more than three times as fast as potassium, but such is not the case.

2. Three hours at room temperature.

Sb	0·055 grm.	0·055 grm.
K	0·043 „	0·0405 „

3. One hour at room temperature.

Sb	0·0146 grm.	0·0135 grm.
K	0·0128 „	0·0109 „

4. At 60° C. One hour test with a 5 per cent solution.

Sb	0·0505 grm.	0·0634 grm.
K	0·0323 „	0·0319 „

5. A half hour test.

Sb	0·0275 grm.	0·0312 grm.
K	0·0175 „	0·0213 „

6. With the assistance of Olin Cantwell, of the Biological Department, we placed a cat under chloroform and slit a portion of the intestines sufficiently to introduce 10 cc. of the 5 per cent solution of tartar emetic. We placed this living tissue in a beaker of distilled water kept at body temperature, allowing it to remain one hour. Osmosis did not seem to take place, as we failed to find any trace of the double salt in the distilled water.

7. We next removed a portion of the intestine from the animal, and after twenty-four hours placed 10 cc. of the 5 per cent tartar emetic A solution inside, and introduced this portion into distilled water for one hour at room temperature. The results are as follows:—

Sb	0·0175 grm.
K..	0·0304 „

B. *Experiments with Rochelle Salts*—

CH(OH)COOK.
|
CH(OH)COONa

1. 10 per cent solution. Six hours at room temperature.

	No. 1 dialyser.	No. 2 dialyser.
K	0·2808 grm.	0·4807 grm.
Na.. ..	0·092 „	0·1357 „

2. Three hours at room temperature.

K	0·0419 grm.	0·1228 grm.
Na.. ..	0·0648 „	0·0500 „

3. The same solution. One hour at room temperature.

K	0·0336 grm.	0·0297 grm.
Na.. ..	0·0154 „	0·0113 „

4. 10 per cent solution at 60°. One hour.

K	0·1240 grm.	0·1172 grm.
Na.. ..	0·1104 „	0·092 „

5. One-half hour.

K	0·0624 grm.	0·0717 grm.
Na.. ..	0·0294 „	0·0271 „

One-fourth hour.

K	0·0682 grm.	0·0717 grm.
Na.. ..	0·0294 „	0·0271 „

7. We tested the living tissue in a cat as in the foregoing experiment with tartar emetic. We placed 35 cc. in a portion of the intestine, and kept it in distilled water for an hour at blood temperature. Diffusion through the membrane did not take place.

We removed the intestine and immediately placed it with the solution in distilled water kept at blood temperature for one hour, with the following results:—

K	0·0130
Na	0·0374

9. We next let the intestine stand for fourteen hours, and then placed within it 30 cc. of the 10 per cent solution of Rochelle salt. This stood in distilled water at room temperature for an hour. The following result was obtained:—

K	0·0916
Na	0·1676

The results seem to indicate that diffusion through dead or artificial tissue is very different from the diffusion through the living tissues.

Cornell College, Mount Vernon, Iowa,
July 5, 1919.

THE RELATIVE STABILITY OF HALOGEN SUBSTITUTED ALIPHATIC ACIDS IN WATER SOLUTION.*

II. THE PROPIONIC ACID AND BUTYRIC ACID SERIES.

By G. S. SIMPSON.

(Concluded from p. 53).

THE hydrolysis of sodium α,α-dibromopropionate, in which both halogen atoms are removed, is of the same nature as sodium dichloroacetate that has been discussed in a previous paper (*loc. cit*). It shows that the introduction of a second halogen into the α-position renders the compound much more stable.

In the hydrolysis of the sodium salts of α,β-dichloropropionic acid and α,β-dibromopropionic acid under the conditions of experiment only the β-halogen was replaced, producing α-halogen sebstituted hydracrylic acid. In both cases it was found that the presence of the halogen in the α-position, which was not removed, greatly increased the stability of the salt.

The hydrolysis of sodium α-chlorobutyrate has not been studied previously. It was found to be more unstable than sodium chloroacetate and sodium α-chloropropionate. This is in accord with the work of Senter on sodium α-bromobutyrate (*Trans. Chem. Soc.*, 1909, xcv., 1827. This shows that the acid becomes more unstable with the increase in sixe of the group substituted into chloroacetic acid. The work of Senter on the hydrolysis of sodium α-bromobutyrate has been repeated to compare its stability with sodium α-chlorobutyrate and sodium α-bromoisobutyrate at 70°. Sodium α chlorobutyrate was found to be more stable than the corresponding bromine compound, as is shown in Table II., C, D.

The hydrolysis of sodium α-bromoisobutyrate was found to proceed very rapidly at room temperature. For this reason it was found necessary to carry out the hydrolysis in flasks at 25° and 35° in a water thermostat. At definite time intervals 15 cc. portions of the solution were drawn off in a pipette, added to ice water, and immediately titrated in flasks which were chilled by an ice-salt bath. It will be noted from the tables that the values for K are fairly constant at 25° but at 35° decrease rapidly as the reaction proceeds. The values calculated for the hydrolysis at 70° are derived from the results at 35° by means of the temperature coefficient and can only approximate the true figures. It will also be evident that these temperature coefficients decrease rapidly as the reaction progresses.

* From the *Journal of the American Chemical Society*, xl., No. 4.

Table II.—*Sodium α,β-Dichloropropionate, Sodium α,β-Dibromopropionate, Sodium α-Chlorobutyrate, and Sodium α-Bromobutyrate in* 0·1 N *Solution at* 70°.

A. Sodium α,β-Dichhloropropionate.

t (min.).	Cc. 0·1 N NaOH.	Cc. 0·1 N $AgNO_3$	10^5 K.
0	0·10	0·15	—
720	2·20	2·65	25·0
1440	4·20	4·75	24·9
2880	7·50	7·90	24·6
4320	9·80	10·15	24·5
5760	11·18	11·60	24·0
7200	12·15	12·75	14·1
9360	13·20	13·73	23·6
∞	14·90	15·38	—

B. Sodium α,β-Dibromopropionate.

t (min.).	Cc. 0·1 N NaOH.	Cc. 0·1 N $AgNO_3$	10^5 K.
0	0·75	1·10	—
60	2·10	2·65	190
180	5·75	6·35	250
360	8·60	9·10	226
600	10·90	11·25	203
840	11·70	12·15	176
1380	13·20	13·66	157
2100	14·60	15·03	160
∞	15·10	15·50	—

C. Sodium α-Chlorobutyrate.

t (min.).	Cc. 0·1 N NaOH.	Cc. 0·1 N $AgNO_3$	10^5 K.
0	0·20	0·20	—
120	2·10	2·40	134
240	3·80	4·03	124
420	5·65	5·90	116
660	7·60	7·75	108
1260	10·30	10·50	94
1980	12·00	12·30	86
2820	12·75	13·05	72
∞	14·70	15·00	—

D. Sodium α-Bromobutyrate.

t (min.).	Cc. 0·1 N NaOH.	Cc. 0·1 N $AgNO_3$	10^5 K.
0	1·35	1·55	—
15	4·70	5·20	2240
30	6·75	7·25	1970
60	9·25	9·88	1720
90	10·55	11·05	1510
120	11·45	11·83	1380
165	12·30	12·75	1280
225	12·60	13·15	1080
∞	14·10	14·28	—

Table III.—*Velocities of Hydrolysis of Sodium β-Chlorobutyrate in* 0·1 N *Solution at* 70°.

t (min.).	Cc. of 0·1 N NaOH.	Cc. of 0·1 N $AgNO_3$.	10^5 K.
0	0·60	1·80	—
10	2·70	5·00	3020
20	4·30	7·17	2790
30	5·20	8·30	2490
45	7·15	10·23	2440
60	8·30	11·08	2440
75	9·00	11·90	2180
120	9·90	12·87	1760
∞	10·25	14·40	—

Although β-chloro-butyric acid has not been previously studied, β-bromobutyric acid has been hydrolysed acid has been hydrolysed at 38° by Johannsen. At this temperature he found that this acid decomposed to produce β-butyrolactone, which he isolated and studied. The hydrolysis of sodium β-chlorobutyrate at 70° clearly indicates the formation of this lactone, by the great difference in titrations with sodium hydroxide and silver nitrate, but at this temperature this lactone has been partially hydrolysed to form α-hydroxybutyric acid. The chlorobutyric acid is shown to be less stable than the isomeric α-chlorobutyric acid and the homologous β-chloropropionic acid.

Table IV.—*Velocities of Hydrolysis of Sodium α-Bromoisobutyrate in* 0·1 N *Solution at* 25°.

t (min.).	Cc. of 0·1 N NaOH.	Cc. of 0·1 N $AgNO_3$.	10^5 K.	Temp. coeff. 25—35°.
0	0·95	1·45	—	—
15	1·90	2·50	685	4·75
30	3·00	3·40	662	4·53
60	4·30	5·00	667	4·27
120	6·60	7·30	646	4·03
180	7·95	8·85	633	3·78
270	9·30	9·90	628	3·52
360	10·05	10·50	663	3·12
∞	12·03	12·30	—	—

Table V.—*Velocities of Hydrolysis of Sodium α-Bromoisobutyrate in* 0·1 N *Solution at* 35° *and* 70°.

t (min.).	Cc. of 0·1 N NaOH.	Cc. of 0·1 N $AgNO_3$.	10^5 K at 35°.	K at 70° (calc.).
0	2·20	2·80	—	—
5	3·50	4·30	3380	8·37
10	4·60	5·30	3100	5·87
20	6·30	7·05	2860	4·62
40	8·30	9·00	2750	3·60
60	9·37	10·07	2350	2·45
90	10·50	11·00	2140	1·76
120	11·05	11·57	2020	1·09
∞	12·10	12·43	—	—

This investigation in addition to showing the relative stability of several halogen substituted aliphatic acids, has furnished considerable evidence on the mechanism of the hydrolysis of their alkali salts.

The intermediate formation of a lactone in the hydrolysis of the β-halogen substituted aliphatic acids recently described by Johannsen (*loc. cit.*) has been indicated in these results. We may also expect that an intermediate lactide has been formed similarly in the hydrolysis of α-substituted aliphatic acids under the conditions of these experiments.

New evidence has been found in support of the explanation advanced by Senter (*Trans. Chem. Soc.*, 1915, cvii., 908) to account for the decrease in the rate of reaction during the hydrolysis of sodium phenylchloroacetate. The best example of such a case found in this investigation is that of sodium α-bromoisobutyrate, for which the following explanation is offered. In decinormal solutions the salts may be considered completely dissociated so that the hydrolysis takes place between water and the α-bromoisobutyric ion, thus:—

$$(CH_3)_2CBrCOONa \rightarrow (CH_3)_2CBrCOO^- + Na^+$$

$$(CH_3)_2CBrCOO^- + HOH \rightarrow (CH_3)_2COHCOO^- + H^+ + Br^-$$

As α-bromoisobutyric acid is not so highly dissociated as its sodium salt an equilibrium is formed between the α-bromoisobutyric and hydrogen ions and the undissociated acid—

$$(CH_3)_2CBrCOO^- + H^+ \rightleftharpoons (CH_3)_2CBrCOOH.$$

The undissociated α-bromoisobutyric acid may also be hydrolysed, but Senter has shown that acids react in this manner much slower than the ions (*Trans. Chem. Soc.*, 1915, cvii., 908). De Barr has shown that high temperatures are required to decompose the free acids, so we should expect that the latter reaction would be negligible at sufficiently low temperatures and then the value of K should be constant (*Am. Chem. Journ.*, 1899, xxii., 336). Such a condition has been realised in the hydrolysis of sodium α-bromoisobutyrate at 25°, but at 35° the decreasing values of K indicate the activity of undissociated α-bromoisobutyric acid in the reaction. This experiment also shows that hydrobromic acid formed by the reaction does not act as a negative catalyst in this case, although Senter has been able to measure its influence in the hydrolysis of α-bromopropionic acid, phenylchloroacetic acid, and phenylbromo-

acetic acid (*Trans. Chem. Soc.*, 1911, xcix., 1049; 1915, cvii., 908; 1916, cix., 681).

Some very interesting speculations are found in applying this theory to the hydrolysis of salts of dihalogen substituted aliphatic acid in which both halogens are replaced. Examples of such salts are sodium *a,a*-dibromopropionate of this article and sodium dichloroacetate previously discussed (Drushel and Simpson, *loc. cit.*). The equations for the hydrolysis of the latter salt according to the above theory would be written thus:—

$$CHCl_2COONa \rightarrow CHCl_2COO^- + Na^+$$

$$CHCl_2COO^- + HOH \rightarrow CHOCOO^- + 2H^+ + 2Cl^-$$

$$CHOCOO^- + H^+ \rightleftarrows CHOCOOH$$

$$CHCl_2COO^- + H^+ \rightleftarrows CHCl_2COOH$$

$$CHCl_2COOH + HOH \rightarrow CHOCOO^- + 2H^+ + 2Cl^-$$

From this it is evident that the concentration of undissociated dichloroacetic acid is relatively great compared with the concentration of chloroacetic acid during the hydrolysis of sodium chloroacetate due to the greater number of hydrogen ions. This explains the unusually large decrease in the rate of reaction as hydrolysis proceeds.

If this hypothesis is correct it explains the stability of *a,β*-dichloropropionic acid, chloroacetic acid, and iodoacetic acid previously described, toward water at 70°, as their rates of reaction are constant at this temperature. From these experiments it is evident that there is no secondary action due to the hydrolysis of undissociated halogen substituted acid at 70°. This point must be proved by later investigation.

Summary.

From the results of this work the relative stability of the several halogen substituted and propionic and butyric acids is expressed by Table VI.

TABLE VI.—*Relative Stabilities.*

Propionic Acid Series.	
β-Bromopropionic acid	1·0
β-Iodopropionic acid	1·03
a-Bromopropionic acid	3·31
β-Chloropropionic acid	7·17
a,a-Dibromopropionic acid ..	10·96
a,β-Dibromopropionic acid ..	18·68
a-Chloropropionic acid	37·06
a,β-Dichloropropionic acid ..	186·8
Butyric Acid Series.	
a-Bromoisobutyric acid	1·0
β-Chlorobutyric acid	277·0
a-Bromobutyric acid	374·0
a-Chlorobutyric acid	6171·0

1. Chlorine substituted aliphatic acids are more stable than the analogous bromine or iodine compounds.
2. The evidence indicates that some iodine substituted aliphatic acids are more stable than the analogous bromine compounds.
3. *a*-Halogen substituted acids are more stable than isomeric *β*-halogen substituted acids.
4. The effect of position on the stability of a halogen substituted acid is greater than the identity of the halogen.
5. The replacement of a hydrogen atom on the carbon atom carrying the halogen by an aliphatic radicle renders the acids less stable.
6. The replacement of a second hydrogen atom on the carbon atom carrying the halogen by an aliphatic radicle greatly decreases the stability of the acid.
7. The larger the aliphatic group substituted the more unstable the acid becomes.
8. The presence of a second halogen in the *a*-position of the acid (irrespective of the replacement of that second halogen) renders the removal of the first halogen in either the *a*- or *β*-positions more difficult.

The writer is indebted to W. A. Drushel for his co-operation in this work.

ON THE
SEPARATION OF GERMANIUM FROM ARSENIC BY THE DISTILLATION OF THE CHLORIDE IN THE PRESENCE OF A CHROMATE.

By PHILIP E. BROWNING and SEWELL E. SCOTT.

IN a recent paper from the Kent Chemical Laboratory of Yale University (*Am. Journ. Sci.*, 1917, [4], xlvi., 313) we described a modification of Buchanan's method (*Journ. Ind. and Eng. Chem.*, 1916, viii., 585) for the separation of germanium from arsenic in which the modifications consisted of a simplified form of apparatus for the distillation, and the substitution of potassium permanganate for the current of chlorine used by Buchanan. An excuse for the presentation of this modified method was to avoid the necessity of the use of chlorine gas which involved certain unpleasant features and a rather more elaborate form of apparatus than is convenient for quick qualitative tests.

The object of the use of oxidising agents in this process is to convert any arsenic present into the arsenic condition, and thus prevent the formation of volatile arsenious chloride which would distil over with the germanium chloride. The present paper is a description of another modification in which chromic acid is used to bring about the oxidation. Kessler (*Pogg. Ann.*, 1855, xcv., 204) has used the reaction between chromic acid and arsenious acid as the basis of a method for the volumetric estimation of arsenious acid, and one of us applied the same reaction in a paper published from this laboratory (*Am. Journ. Sci.*, 1896 [4], i., 35) for the estimation of chromic acid.

The apparatus used may be briefly described as follows— The distillation flask consisted of a Pyrex glass Erlenmeyer beaker of about 75 cc. capacity fitted with a two-hole rubber stopper. Through one of these openings a bent glass tube was inserted, the other end of which was placed just below the surface of about 3 cc. of water in an ordinary test-tube immersed in a beaker containing crushed ice or cold water to aid the condensation. Through the second opening in the stopper another tube was inserted so as to have its end about 1 cm. below the surface of the liquid to be distilled. This tube was connected through a wash bottle with a carbon dioxide generator, so that the gas could be used to facilitate the boiling of the liquid, the distillation of the volatile chloride, and finally aid in the removal of any chlorine which might result from the action of the hydrochloric acid upon the excess of chromate present.

In this flask the material, consisting of a mixture of arsenious oxide and germanium oxide, was placed, and in our experiments about 5 cc. of a 10 per cent solution of potassium dichromate, together with a few drops of sulphuric acid. This mixture was then warmed for about a minute, when the oxide dissolved and the arsenious acid was oxidised to arsenic acid. About 10 cc. of strong hydrochloric acid was added and the distillation was made in a current of carbon dioxide until about one half of the liquid was distilled, and the current of carbon dioxide was continued until the liquid in the distillation flask was cool.

The distillate was then tested by hydrogen sulphide to detect the presence of the yellow As_2S_3, or the white GeS_2. The results follow in the Table.

Experiments 1-7 were carried out with varying amounts of arsenious oxide only, to determine the amount of

arsenic which would be oxidised by about 0·5 grm. of potassium dichromate. It was found that 0·2500 grm. of arsenious oxide could be successfully oxidised by this amount of that reagent. In experiments (6) and (7) some water and less hydrochloric acid was used without interfering with the oxidation. In experiment (8) neither arsenic nor germanium were present, the object being to determine the possible interfering action of chlorine evolved upon the test with hydrogen sulphide. The result was satisfactory. In experiments (9) and (10) small amounts of germanium oxide were used and a very satisfactory result was obtained when only 0·0005 grm. was present. Finally in experiments (11) and (12) a mixture of the two oxides was treated according to the method, and it was found that 0·0005 *grm.* of germanium oxide could be readily detected when present with 0·1 grm. arsenious oxide.

TABLE I.

	As_2O_3 present grm.	GeO_2 present grm.	10 $K_2Cr_2O_7$ present cc.	Strong HCl present cc.	Water present cc.	Result on treating distillate with H_2O.
1.	0·0500	—	5	10	—	No ppt.
2.	0·2000	—	5	10	—	No ppt.
3.	0·5000	—	5	10	—	As_2S_3
4.	0·3000	—	5	10	—	As_2S_3
5.	0·3000	—	5	10	—	As_2S_3
6.	0·2000	—	5	3	5	No ppt.
7.	0·2500	—	5	6	5	No ppt.
8.	—	—	5	5	5	No ppt.
9.	—	0·0050	5	6	5	GeS_2
10.	—	0·0005	5	10	5	GeS_2
11.	0·1000	0·0010	5	10	5	GeS_2
12.	0·1000	0·0005	5	10	5	GeS_2

This reaction is also well adapted to the use of the simplified form of apparatus described in our previous paper.—*American Journal of Science*, xlvi., 663.

VACUUM ARC SPECTRA OF VARIOUS ELEMENTS IN THE EXTREME ULTRA-VIOLET.*

By Prof. J. C. McLENNAN, F.R.S.; D. S. AINSLIE, M.A., and D. S. FULLER, M.A., University of Toronto.

1. *Introduction.*

IN the prosecution of the work on ionisation potentials recently set in train by one of us, it becomes of importance to extend the development to include an examination of the series spectra of certain of the elements farther down in the ultra-violet region than was accessible with an optical system of quartz.

In order to carry out this extension of the work a small 60° prism and two bi-convex lenses of about 15 cm. focal length for the visible range of wave lengths, all of good quality fluorite, were made for us by the Adam Hilger Co., and these optical parts were used in the construction of a spectrograph made up in the laboratory workshop of the University of Toronto after our own design.

Great difficulty was experienced in developing the instrument to a stage which would enable one to make rapid and satisfactory progress with it. The working out of a satisfactory arrangement of devices for establishing and maintaining at will an arc *in vacuo* was found especially trying, but eventually the main difficulties were overcome. The most rapid progress could be made, it was found, by cutting out all more or less complicated arrangements and using only the simplest possible operating attachments.

2. *Apparatus.*

The general characteristics of the spectrograph will be readily seen from the sketch shown in Fig. 1. The prism was mounted on a platform in a central brass chamber from the two opposite sides of which projected a brass collimator tube and a brass tube terminated by a plate holder. This latter consisted of a shallow rectangular box carrying a frame which could be slightly rotated when adjustment was necessary. The box was provided with an opening at one end through which the photographic plate could be slipped into position. When the plate was in position and ready for an exposure, the opening was closed with a small brass cap and the joint made air-tight by means of a rubber washer. The operation of inserting the plate and of closing the opening in the plate holder was, of course, carried out in the dark. The photographic plates used were narrow strips cut from Schumann plates recently prepared and put on the market by the Adam Hilger Co.

In the course of the experiments it was found necessary to remove all water vapour from the spectrograph in order to secure the best photographic results in the region of shorter wave-lengths. For this purpose a large cylindrical brass drying chamber, shown in Fig. 1, was attached to the collimating tube. Through a narrow opening in one end of this chamber it was possible to insert or remove when desired a shallow tray filled with phosphorus pentoxide. The plate P, Fig. 1, provided with a rubber washer enabled one to close the opening quite satisfactorily.

The collimator tube was provided with two closely fitting tubes, A and B, concentric with it. One of these, A, carries a disc in which was inserted the condensing fluorite lens, and the other, B, carried a plate to which the slit jaws were attached. The focussing fluorite lens was

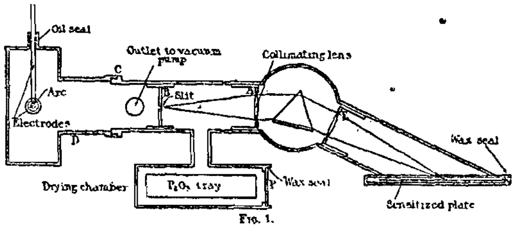

FIG. 1.

carried on a disc borne by a sliding tube, E, similar to A and B. The edges of the discs which carried the lenses were pierced with a number of holes so that the air had free access through them to all parts of the instrument.

The air was removed from the apparatus by means of a set of oil-sealed mechanical Trimount pumps, the connections being made with lead piping at the points shown in the figure.

Before the instrument was used with a vacuum arc the slit, lenses, and prisms were all carefully adjusted so that with an aluminium spark in air as a source the lines in the neighbourhood of λ 1858 A, as well as those up to λ 2200 A, could be seen clearly focussed and well up on the right-hand side of the plate.

Various forms of "lamp" or "lantern" were tried out without success, but the simple arrangement shown in Fig. 1 was finally adopted as giving the best and at the same time quite satisfactory results.

The arrangement consisted of a T-tube, D, attached to the collimator by means of a shoulder at C. One electrode was led in from below and the other through the end of the "lantern." When soft metals were used the lantern was turned through an angle of approximately 45°, so that both the electrodes were at an angle with the vertical.

Flexible joints with oil seals were used with each of the electrodes, so that they could be readily adjusted without allowing any air to enter the spectrograph. The electrodes were originally insulated with ebonite bushings, but in later work, where high temperature arcs were used, the ebonite was replaced by porcelain bushings. The lantern was provided with a window of glass through which the arc could be viewed.

* From the *Proceedings of the Royal Society*, A, xcv., 316.

A short glass Geissler tube, not shown in the diagram, was connected with the spectrograph. The terminals of a small 4-volt induction coil were attached to this tube, and when the discharge from the coil was sent through it the appearance of the discharge served as a guide to estimate the degree of exhaustion attained within the instrument.

The Trimount pumps were found to be exceedingly efficient. When all leaks were stopped and the pumps put into operation, the cathode ray vacuum was obtained in a few minutes. Initially, the apparatus was exhausted several times and washed out with hydrogen before steps were taken to make an exposure. After the last washing the pumps were kept running for a quarter of an hour before an exposure was made. At this stage the Geissler tube showed a faint greenish yellow fluorescence similar to that exhibited by a "hard" X-ray tube. In the later experiments it was found that washing out with hydrogen was not necessary when plenty of phosphorus pentoxide was used. The arc used in the experiments was produced by joining the electrodes to the 220-volt D.C. mains with a suitable resistance in series to regulate the current. The arc was established by simply bringing the ends of the electrodes together and then drawing them slightly apart.

With substances having a high fusion point such as copper, the temperature of the arc was not sufficient to melt the metal and the arc was of an intermittent nature giving an intense flash on each break when a current of 8 to 15 amperes was used on closed circuit.

For metals of low melting-point quartz tubes were originally placed around the metal, leaving a small end projecting so as to permit electrical contact to be made. When the arc was once started the metal at the top of the electrode melted and a continuous intense source of light was secured with a current of from 4 to 6 amperes. In the later experiments with soft metals it was found to be more convenient to place the metal in hollows made in the ends of two iron rods used as electrodes. The time of exposure was equivalent to about five minutes continuous arcing.

By one or other of the methods indicated above, arc spectra for copper, aluminium, zinc, carbon, iron, tin, thallium, lead, nickel, cobalt, and cadmium were obtained.

In la er work, a hydrogen discharge tube of the end-on type was constructed so as to fit in the socket at the end of the collimator, which was also used for attaching the vacuum arc lamp. A fluorite window was sealed in the end of the discharge tube through which the light p ssed to the slit. The discharge was obtained by attaching the tube to a small induction coil without additional capacity in the circuit. In addition to the spectrum of hydrogen, several lines were obtained corresponding to the main lines of the carbon monoxide spectrum as given by Lyman. This, no doubt, was due to an impurity in the hydrogen used in the discharge tube.

In order to compare the metal spectrum with that of hydrogen, an adjustable cover was provided for the slit, so that one half of the slit could be exposed for the metal arc and the other half for the gas discharge. By means of this slit cover the metal and gas spectra were photographed on the same plate one above the other.

In working with metal arcs the secondary hydrogen spectrum was always present along with the metal spectrum. The lines due to this gas effect were, however, easily picked out by having the metal and hydrogen spectrum photographed together on the same plate. When an intermittent arc with a small current was used the time of exposure was longer, and the secondary spectrum came up strong, while with higher currents the arc remained much steadier, and the secondary spectrum was relatively much weaker.

3. *Method of Determining Wave-lengths.*

In calculating the wave-lengths of the lines in the different spectra certain lines previously measured were used as standards. From these the wave-lengths were determined by means of graphical interpolation. In making a calibration curve the hydrogen and aluminium lines as measured by Lyman were used for the region from λ 1858 A down. For the region above λ 1800 A, carbon monoxide lines as given by Lyman, together with copper and thallium lines as measured by Eder and Valenta, were used. The plates themselves were measured with a Hilger comparator, and the average of results from several plates was used in each case. A list of lines used as standards is given in Table I., together with their wave-lengths and the name of the observer.

Table I.—*Calibration Wave-lengths.*

Source.	Wave-length.	Observer.
Tl	2394·7 A	E. and V. (*a*)
Tl	2379·64	,,
Cu	2369 95	,,
Cu	2247·08	,,
Cu	2195 87	,,
Tl	2139 44	,,
Al	1989 9	Lyman (*b*)
CO	1970 1	,,
Al	1930 4	,,
CO	1898·0	,,
Al	1862·8	,,
CO	1792·6	,,
Al	1761 9	,,
CO	1712·2	,,
Al	1670 6	,,
CO	1630·3	,,
Al	1611·8	,,
Al	1605·6	,,
H	1602·0	,,
H	1589·0	,,
H	1581·0	,,
H	1553·3	,,
H	1515·0	,,
H	1491·9	,,
H	1463 9	,,
H	1441·0	,,
H	1436·3	,,
H	1427 8	,,
H	1402·8	,,
H	1397·5	,,

(*a*) E. and V., Eder and Valenta, "Atlas Typischer Spektren."
(*b*) Lyman, "Spectroscopy of Ultra-violet," p. 109.

(To be continued).

NOTES.

New Books.—Hodder and Stoughton have in the press "The New Teaching Series" of text-books. The volumes already in hand include: —"Chemistry from the Industrial Standpoint" and "Chemistry and Bacteriology of Agriculture." It is claimed that the series will represent a new departure in text-books.

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THE CHEMICAL NEWS

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THE PREPARATION OF ORGANIC STANNO- AND STANNI-CHLORIDES.

Part III.—Compounds of the Amino Acids.

By J. G. F. DRUCE, B.Sc., A I.C.

As might be anticipated, the tendency to form stanno- and stanni-chlorides was found to be less marked with the amino-acids than with the amines.

It has been found possible, however, to prepare a series of double salts of certain aromatic amino-acids with stannous and stannic chlorides.

The methods used for the preparation of these compounds were the same as those adopted in the previous work (Chemical News, 1919, cxviii., 1 and 87).

o-*Amidobenzoic Acid Stannochloride*, $C_6H_4<^{NH_2,HSnCl_3}_{COOH}$.

o-Nitrobenzoic acid (1·7 grm.) was warmed in a conical flask with 3·6 grms. of granulated tin and 30 cc. of concentrated hydrochloric acid diluted with an equal volume of water. When all the metal had dissolved the liquid was transferred to a basin, and on cooling deposited a mass of colourless microscopic crystals, which were filtered off, washed with a little dilute hydrochloric acid, drained, and dried on a porous plate in air.

The salt dissolved in cold water, giving a clear acid solution which rapidly hydrolysed, however, on standing, or immediately on gentle warming, unless dilute mineral acid was added. It dissolved in cold alcohol and the solution remained clear on boiling. It was insoluble in chloroform, carbon tetrachloride, toluene, ligroin, and ethyl acetate. On heating, the substance began to soften at 85° and melted completely at 125° to a colourless liquid.

The hydrochloric acid solution gave a white precipitate with mercuric chloride solution, and hydrogen sulphide gave the brownish black precipitate of stannous sulphide.

o-Amidobenzoic acid stannochloride was also prepared from the component salts. *o*-Amidobenzoic acid (1·37 grms.) and stannous chloride (2·26 grms.) were dissolved together in 20 cc. of concentrated hydrochloric acid and 30 cc. of water by heating. On cooling, a mass of very short colourless needles separated. They were identical with the product obtained above. On analysis—

1·8144 grms. gave 0·8832 grm. SnO_2; Sn = 33·18 per cent.
0·5687 grm. gave 0·6703 grm. AgCl; Cl = 29·17 per cent.
$NH_2.C_6H_4.COOH,HSnCl_3$ requires Sn = 32·79; Cl = 29·37 per cent.

o-*Amidobenzoic Acid Stannichloride*, $(NH_2.C_6H_4.COOH)_2H_2SnCl_6$.

The stannochloride (3 grms.) was dissolved in 40 cc. of dilute hydrochloric acid and chlorine was slowly passed through the solution for three hours. At the end of this time the solution gave no precipitate with a solution of mercuric chloride. The solution was concentrated on a water-bath until crystals formed; on cooling, slightly deliquescent needle prisms separated. These were easily soluble in cold water, but the solution readily hydrolysed. They dissolved in alcohol but not in other organic solvents.

The salt was also prepared from mixed solutions of the amido-acid (2·7 grms.) and stannic chloride (3·5 grms.). On analysis both products were found to have the same composition—

0·8238 grm. gave 0·2376 grm. SnO_2; Sn = 19·34 per cent.
1·0362 grm. gave 1·4683 grm. AgCl; Cl = 35·06 per cent.
$(NH_2.C_6H_4.COOH)_2H_2SnCl_6$ requires Sn = 19·60 and Cl = 35·12 per cent.

m-*Amidobenzoic Acid Stannochloride*, — $(NH_2.C_6H_4.COOH)_2H_2SnCl_4$.

m-Nitrobenzoic acid (6·7 grms.) was reduced with 7·2 grms. of tin and 100 cc. of concentrated hydrochloric acid diluted with 50 cc. of water. The mixture was warmed in a conical flask until the metal had dissolved, and was then filtered whilst hot into a basin. When cold a crop of white granular crystals separated. On examination this first crop of crystals was found to be the hydrochloride of *m*-amidobenzoic acid.

The filtrate was concentrated on a water-bath and on cooling it deposited a feathery mass of fine needle crystals of the stannochloride, easily distinguished from the above granules.

The double salt was also prepared from 1·5 grms. of *m*-amidobenzoic acid and 2·9 grms. of stannous chloride, dissolved in 50 cc. of dilute hydrochloric acid by warming. A mass of fine needle crystals similar to those obtained above, separated and were isolated and examined. The filtrate also yielded more of the compound on standing.

Crystals obtained by both methods melted at 240°, and were not very soluble in water even when warm. The solution was strongly acid, and boiling did not cause hydrolysis. The salt dissolved readily in warm dilnte hydrochloric acid; it was slightly soluble in alcohol, but insoluble in chloroform, toluene, &c. On analysis—

0·6433 grm. gave 0·2861 grm. SnO_2; Sn = 21·42 per cent.
0·2269 grm. gave 0·2403 grm. AgCl; Cl = 26·20 per cent.
$(NH_2.C_6H_4.COOH)_2H_2SnCl_4$ requires Sn = 22·11; Cl = 26·43 per cent.

m-*Amidobenzoic Acid Stannichloride*, $(NH_2.C_6H_4.COOH)_2H_2SnCl_6$.

The above stannochloride (4 grms.) dissolved in 50 cc. of dilute hydrochloric acid was submitted to the action of chlorine for two hours until the solution no longer gave the reactions for stannous tin. The solution was concentrated on a water-bath and deposited a small quantity of pale yellow granular crystals on cooling and standing over the week-end.

This substance darkened indefinitely at 220–230° and was found to contain a very low percentage of tin (about 1 per cent). It was a chlorination product. The hydrochloride of *m*-amidobenzoic acid was also obtained from insufficiently concentrated solutions, in the preparation of the stannichloride by this and other methods.

The second crop of crystals were colourless, short radiating needle masses, entirely distinct from the yellow granules.

The salt dissolved easily and completely in cold water, and the solution could be boiled without showing signs of hydrolysis. On passing hydrogen sulphide through the solution, yellow stannic sulphide was precipitated. It melted at 193°.

The stannichloride was also obtained from *m*-amidobenzoic acid (2·76 grms.) and stannic chloride (3·57 grms.) dissolved to a clear solution in 50 cc. of dilute hydrochloric acid by warming. This solution deposited a mass of very pale brown short needles, melting at 190—192°.

Almost colourless short needles were obtained from mixed solutions of *m*-nitrobenzoic acid (3·34 grms.) and stannous chloride (13·5 grms.) in aqueous alcoholic hydrochloric acid. On analysis—

1·1413 grm. gave 0·2921 grm. SnO_2; Sn = 20·15 per cent.
1·1413 grm. gave 1·9428 grm. AgCl; Cl = 35·03 per cent.
The above formula requires Sn = 19·60; Cl = 35·12 per cent.

p-*Amidobenzoic Acid Stannichloride*, $(NH_2.C_6H_4.COOH)_2H_2SnCl_6$.

p-Amidobenzoic acid (2·76 grms.) and stannic chloride (3·57 grms.) were dissolved together in 70 cc. of dilute hydrochloric acid by warming. Small pale yellow brittle needles separated out on cooling. They were filtered off, drained, dried, and examined.

They dissolved readily in cold water to a clear solution which was strongly acid, and became cloudy when heated. The crystals did not dissolve in organic solvents, and did not melt up to 315°. On analysis—

0·2738 grm. gave 0·0710 grm. SnO_2; Sn = 20·51 per cent.
0·2738 grm. gave 0·3957 grm. AgCl; Cl = 34·75 per cent.
The above formula requires Sn = 19·60 and Cl = 35·12 per cent.

p-Amidobenzoic acid stannichloride was also obtained by reductiou of 1·6 grms. of *p*-nitrobenzoic acid (obtained from *p*-nitrotoluene by oxidation with potassium permanganate) with 6·7 grms. of stannous chloride in 100 cc. of dilute hydrochloric acid. The product was identical with that prepared above in analysis and did not melt up to 310°.

Attempts to prepare *p*-amidobenzoic acid stannochloride unsuccessful. Reduction of *p*-nitrobenzoic acid with tin and hydrochloric acid yielded a dark solution, which was not decolorised by the use of excess of tin. No crystalline product was isolated in a pure state. The dark amorphous mass left on evaporation to dryness on a water-bath, was washed on a filter-paper with dilute acid, drained, dried in a steam-oven, and analysed. It was found to possess a tin-content which varied in different experiments, depending upon the quantity of metal used and the length of washing with acid.

Mixed solutions of *p*-amidobenzoic acid and stannous chloride in dilute hydrochloric acid on concentration deposited short pale yellow needle prisms, which were devoid of tin, and were those of *p*-amidobenzoic acid hydrochloride. No pure stannochloride was isolated from the filtrates.

Sulphanilic Acid Stannichloride,
$(NH_2.C_6H_4.SO_3H)_2H_2SnCl_6$.

Molecular proportions of sulphanilic acid and stannous chloride dissolved in dilute hydrochloric acid did not yield a stannochloride.

Sulphanilic acid (3·46 grms.) and stannic chloride (3·57 grms.) dissolved in 60 cc. of hot dilute hydrochloric acid gave a fine white microcrystalline powder, which was not very soluble in cold water. With warm water metastannic acid separated. The salt did not melt but began to darken and decompose at 270°. On analysis—

0·7621 grm. gave 0·1701 grm. SnO_2; Sn = 17·59 per cent.
0·7621 grm. gave 1·0139 grm. AgCl; Cl = 32·90 per cent.
Per cent Cl by Stepanow's method = 31·33.
$(NH_2.C_6H_4.SO_3H)_2.H_2SnCl_6$ requires Sn = 17·46 and Cl = 31·28.

4-Amidophthalic Acid Stannochloride,
$[NH_2.C_6H_3(COOH)_2]_2H_2SnCl_4$.

4-Nitrophthalic acid (2·3 grms.), prepared according to Miller (*Ann.*, 1881, ccviii., 224), was reduced with tin (4·2 grms.) in 60 cc. of concentrated hydrochloric acid and 60 cc. of water. The mixture was warmed until all the metal had dissolved and was then filtered. A mass of white, very short needles separated out of the filtrate. It was filtered off, washed with dilute acid, drained, and dried on a porous plate. The salt melted sharply at 274°, and dissolved in cold water. Hot water caused hydrolysis. On analysis—

0·3994 grm. gave 0·0944 grm. SnO_2; Sn = 18·59 per cent.
0·3994 grm. gave 0·5806 grm. AgCl; Cl = 35·96 per cent.
The above formula requires Sn = 19·00; Cl = 34·05 per cent.

4-Amidophthalic Acid Stannichloride,
$[NH_2.C_6H_3.(COOH)_2]_2H_2SnCl_6$.

Chlorination of the above stannochloride did not yield the stannichloride pure, other changes accompanied the oxidation of stannous salt to stannic.

The stannichloride was obtained from 4-nitrophthalic acid (2 grms.) and stannous chloride (6·9 grms.) by warming for two hours with 100 cc. of dilute hydrochloric acid. The salt was isolated as small pale yellow crystals, soluble in cold water, giving a clear acid solution. It melted at 182°. On analysis—

0·3206 grm. gave 0·0708 grm. SnO_2; Sn = 17·43 per cent.
0·3206 grm. gave 0·4018 grm. AgCl; Cl = 31·01 per cent.
$[NH_2C_6H_3(COOH)_2]_2H_2SnCl_6$ requires Sn = 17·07; Cl = 30·58 per cent.

The reduction of 3-nitrophthalic acid with tin and hydrochloric acid was carried out as for the 4-compound, but the short needle prisms obtained gave no precipitate with mercuric chloride solution, or when hydrogen sulphide was passed into their acid solution. The substance contained chlorine, and when diazotised with nitrous acid and an alkaline solution of β-naphthol was added, it gave a deep red azo-dye.

Amidosalicylic Acid Stannichloride,
$[NH_2C_6H_3(OH)COOH]_2H_2SnCl_6$.

Nitrosalicylic acid (prepared according to the method of Hirsch, *Ber.*, 1900, xxxiii., 3238) was reduced with tin and hydrochloric acid and gave short dark brown needle prisms, which, however, did not contain tin. When diazotised and treated with an alkaline solution of β-naphthol the product gave a deep red substance.

The reduction of 1·67 grms. of the nitro-acid with 6·78 grms. of stannous chloride was carried out in 30 cc. of strong hydrochloric acid and 30 cc. of alcohol by heating on a water-bath for an hour in a flask fitted with a reflux condenser. The alcohol was evaporated, and the solution deposited small brownish prismatic crystals which melted at 128°. They dissolved in water, but the solution became cloudy on heating. On analysis—

0·9354 grm. gave 0·2084 grm. SnO_2; Sn = 17·55 per cent.
The above formula requires Sn = 18·56 per cent.

o-Nitrocinnamic acid was submitted to the action of tin and of stannous chloride in the presence of hydrochloric acid, but the resulting products were not double tin chlorides.

Glycocoll, the only aliphatic amino-acid employed with a view to preparing the stanno- and stanni-chlorides, was dissolved with molecular quantities of stannous and of stannic chlorides in dilute hydrochloric acid. The concentrated solutions did not crystallise even after standing for some months. Experiments were made to see whether the double salts could be thrown out from the syrupy liquid by shaking with alcohol, ether, or benzene, but all were unsuccessful.

For analysis, a modification of the method mentioned by Pfeiffer (*Ann.*, 1913, cccxcviii., 195) was adopted. The salt was dissolved in a convenient volume of cold water, and an ammonium nitrate solution, containing about the same weight of nitrate as of the substance taken, was added. To this dilute sodium carbonate solution was added until the solution was just alkaline. It was then boiled, and on cooling the precipitate was filtered off, washed, dried, and ignited to stannic oxide and weighed as such. The filtrate and washings were acidified with nitric acid and boiled. Addition of silver nitrate solution precipitated the chloride quantitatively.

City and Guilds of London Institute.—Diplomas of Associate have been awarded by the Council to the following students:—In Engineering—J. D. Aguiar, R. H. Barfield, J. A. A. Best, C. Grad, A. G. Griffith, T. J. Griffiths, F. St. A. Hartley, G. H. Hopewell, E. W. A. Janmoulle (Siemens Medal), A. A. de Lemos, K. P. P. Menon, R. B. McC. Potter, J. H. Reyner (Henrici Medal), C. J. H. Trutch, S. Vaughan, A. C. Warren (Henrici Medal), H. C. Wilkinson, E. W. Workman, R. G. P. Wyatt (Bramwell Medal). In Applied Chemistry—E. Fisher, J. R. Fraser, F. D. M. Hocking, S. J. Hopkins, L. Mendel, N. Plotzker, N. Singer, C. E. Spearing, H. G. Tribley, H. B. Williams.

DETERMINATION OF ZINC AND CALCIUM IN THE PRESENCE OF LEAD.

By ERNEST NYMAN,
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As far as the writer knows chemical literature does not mention the property of lead ferrocyanide and lead oxalate of being soluble in ammi acetate solution, neither the possibility of titrating zinc in ammoniacal solution, using uranyl acetate weakly acidified with hydrochloric acid, as outside indicator. Methods based on these facts are outlined in the following, and may prove useful, particularly in determination of zinc, calcium, and lead in paint pigments, where these elements are apt to be present together. In the work the writer has also proved the relation of the zinc salts precipitated by potassium ferrocyanide in acid and ammoniacal solution, and the different factors for zinc in acetic acid solution and in a solution weakly acid with hydrochloric acid.

Determination of Zinc.

To the acid solution of the salts add NH_4OH till strongly ammoniacal, then make acid with acetic acid, and if a precipitate still remains, add a few grms. of ammonium acetate, heat to boiling, remove from heat, make faintly ammoniacal, and add some $K_4Fe(CN)_6$ solution. The zinc is precipitated as normal zinc ferrocyanide, $Zn_2Fe(CN)_6$, the lead remains in solution, lead ferrocyanide being soluble in ammonium acetate. Neither does Ca interfere.

If, when adding NH_4OH to an acetate acid solution, no precipitate forms, it may indicate either absence of lead or an amount that is soluble in the ammonium acetate formed.

In this way zinc may be determined qualitatively as above, as well as quantitatively, as follows:—

Proceed as above till the faintly ammoniacal solution is obtained, arrange the temperature of the solution to be 70—80° C., add, dropwise, standard $K_4Fe(CN)_6$, stirring thoroughly, and spotting the end-point by the usual reddish brown tinge developed with uranyl acetate on a spot-plate, the spotting modified, as will be indicated in the following:—

This tinge is caused by a faint precipitate of $(UO_2)_2Fe(CN)_6$. In titrating a weakly acid solution this tinge appears as known, when a drop of the solution comes in contact with a drop of the uranyl acetate solution on the spot-plate.

This is not the case when the solution titrated is ammoniacal, because canary-yellow amorphous ammonium uranate is precipitated by the NH_4OH.

$$2UO_2(CO_2CH_3)_2+6NH_4OH—(NH_4)_2U_2O_7+ +CH_3CO_2NH_4+3H_2O.$$

No reddish brown tinge is thus developed, also because the $(UO_2)_2Fe(CN)_6$ possibly formed is soluble in the ammonium uranate:—

$$(UO_2)_2Fe(CN)_6+6NH_4OH—(NH_4)_4Fe(CN)_3+ +3H_2O+(NH_4)_2U_2O_7.$$

But adding a drop of HCl solution, say (1 : 12), to the uranyl acetate drop on the spot-plate before titrating will neutralise any free ammonia, and then the ferrocyanide acts with the acetate forming the reddish brown tinge.

Also it must be remembered that in an ammoniacal solution normal zinc ferrocyanide, $Zn_2Fe(CN)_6$, is precipitated, while in an acid solution this salt is first precipitated, but by adding more of the ferrocyanide gradually changes, giving as a final salt a precipitate of potassium zinc ferrocyanide, $K_2Zn_3[Fe(CN)_6]_2$.

Thus, in an ammoniacal solution a salt containing 1 grm. of zinc is precipitated by 3·2304 grms. of $K_4Fe(CN)_6.3H_2O$ $\left(\frac{422·35}{65·37 \times 2}\right)$, the equation being:—

$$2Zn(CO_2CH_3)_2+K_4Fe(CN)_6 = Zn_2Fe(CN)_6+4KCO_2CH_3,$$

while in an acid solution the same amount of zinc is precipitated by 4·3073 grms. of ferrocyanide,—

$$\left(\frac{422·35 \times 4}{65·37 \times 6}\right)$$

the equation being:—

$$6Zn(CO_2CH_3)_2+4K_4Fe(CN)_6 = =2K_2Zn_3[Fe(CN)_6]_2+12KCO_2CH_3.$$

The theoretical factor for converting the zinc value of the ferrocyanide solution obtained in acid titration to its zinc value in ammoniacal titration thus being—

$$\frac{4·3073}{3·2304} = 1·3333.$$

The practical factor as arrived at from determinations (see below) carried on by the writer is 1·3450. The difference between the factors is satisfactorily small, and is to be attributed to some unavoidable experimental cause, may be, partly, to a difference in sensitiveness of the external indicator to an acid and ammoniacal titration. This being the case, it may be stated that the zinc salts precipitated in ammoniacal and acid solution are identical with the zinc salts of respective formulæ, $Zn_2Fe(CN)_6$ and $K_2Zn_3[Fe(CN)_6]_2$. This corrects the statement found in the literature on the subject, which states that the zinc salts precipitated are not identical with zinc salts of these formulæ, but fairly closely approach the identity.

From the determinations conducted it also appeared that when titrating an acetic acid zinc solution for standardising the ferrocyanide, a constantly lower value of zinc was obtained than when the titration was carried on in weakly HCl acid solution. But this discrepancy vanished, and identical values were obtained if a drop of HCl was added to the uranyl acetate drop on the spot-plate. This shows that a larger excess of $K_4Fe(CN)_6$ is needed to give the reddish brown precipitate in an acetic acid solution than in a HCl acid solution. This also is to be expected; the acetic acid solution being less ionised than the HCl solution. It seems therefore to be necessary, if only one standard ferrocyanide solution is to be used, to standardise this solution with a weakly HCl acid solution, and when an acetic acid zinc solution is at hand to be titrated, either to make it ammoniacal and then weakly acid with HCl; or if the titration is carried on directly in the acetic acid solution to add a drop of HCl to the uranyl acetate drop on the spot-plate.

The standardisation of the potassium ferrocyanide solution in an acetic acid and ammonical zinc solution with the object of determining the factor for converting the value on zinc obtained in an acid solution to the value on zinc for titration in an ammoniacal solution was carried on as follows:—

0·20—0·25 grm. of C.P. electrolytic zinc was dissolved in 10 cc. concentrated HCl, then 10 cc. H_2O added, the solution boiled for a couple of minutes, removed from heat, 20 cc. NH_4OH (1 : 1) added, 5 cc. concentrated HCl added, the solution again boiled for a couple of minutes, cooled, and diluted to 250 cc. at standard temperature. Of this solution 25 cc. portions were pipetted off into 250 cc. beakers. If the object was to titrate in an acetic acid solution the HCl acid zinc solution in the beaker was made ammoniacal to litmus then just acetic acid, 75 cc. water added, the solution heated to nearly boiling, and the titration carried on at 70—80° C., as described in an earlier article by the writer (*Canadian Chem. Journ.*, ii., No. 7), with the exception that a drop of HCl was added to 1 drop of the uranyl acetate (4 per cent) on the spot-plate befor titrating.

The titrating in an ammoniacal solution was conducted in the same way, with the only difference that the acetic acid solution was made slightly ammoniacal. In the ammoniacal solution also the $Zn_2Fe(CN)_6$ precipitated is not flocculent, but more of a colloidal nature, it therefore not being possible to observe the end-point, as the case is in

an acid solution by the momentary complete change of the flocculent $Zn_2Fe(CN)_6$ first precipitated in an acid solution, into the colloidal milky precipitate of $K_2Zn_3[Fe(CN)_6]_2$; it therefore being necessary always to use uranyl acetate as an external indicator when titrating in an ammoniacal solution, while an expert's eye can do without the same when titration takes place in an acid solution. A set of the titrations done in acid and ammoniacal solution will how how the factor 1·3450 was derived :—

·2141 grm. zinc/150 cc. solution. Taken 25 cc. portions.

Titration in acetic acid solution :—

1. 4·20 cc. of $K_4Fe(CN)_6$ used.
2. 4·15 cc. of $K_4Fe(CN)_6$ used.
3. 4·25 cc. of $K_4Fe(CN)_6$ used.
4. 4·20 cc. of $K_4Fe(CN)_6$ used.

Average, 4·20 cc. ; blank, 3 cc.

1 cc. = 0·02141/3·90 = 0·005489 grm. Zn.

In ammoniacal solution :—

1. 3·05. 2. 3·10. 3. 3·10. 4. 3·15.

Average, 3·10 cc. of $K_4Fe(CN)_6$ sed. Blank, 3 cc.

1 cc. = 0·02141/2·90 = 0·007383 grm. Zn.

The factor—0·007383/0·005489 = 1·3450.

The precipitated zinc salt may be filtered off, and the ead determined in the filtrate by the chromate method.

In this connection it may be stated that, contrary to common opinion, the $PbCrO_4$ is to be dried at 100° C. for one hour, the drying may be carried on in a couple of minutes by heating the $PbCrO_4$ in the Gooch, placed in another porcelain crucible that may be exposed to the full heat of a Bunsen flame. Also heating the $PbCrO_4$ in the Gooch directly with a full Bunsen flame seems not to change its composition. The literature states the melting-point of $PbCrO_4$ to be 971° C.

Determination of Calcium.

Proceed as directed above for determination of zinc till the faintly ammoniacal solution is obtained, then add sufficient of a solution of ammonium oxalate. Calcium is precipitated as oxalate, the lead remains in solution, lead oxalate being soluble in ammonium acetate. Neither does Zn interfere.

The lead may be determined qualitatively as well as quantitatively in the filtrate by the chromate method, although to determine it quantitatively the most convenient way is to first precipitate the lead as chromate, determining calcium in the filtrate as oxalate.—*Canadirn Chemical Journal*, iii., No. 7.

"PHYSICAL" *versus* "CHEMICAL" FORCES.*

By P. V. WELLS, Bureau of Standards, Washington, U.S.A.

In his remarkable memoir on the constitution of solids and liquids, Langmuir (*Journ. Am. Chem. Soc.*, 1917, xxxix., 1848) considers in some detail those forces which are concerned in the structure of matter, stating their characteristics with great clearness. But unfortunately he adopts definitions of "physical" and "chemical" forces connoting a narrowness to the term "physical" which is quite unhappy. I realise, however, that his purpose in this is to emphasise the relation of many terms and phenomena usually regarded as distinct.

Science has arrived at a stage in its evolution where the classification between physics and chemistry appears artificial. Of course all classification is necessarily arbitrary, and appears so especially at the boundaries between classes. There must, therefore, be confusion and difference of opinion among those who approach the study of what may perhaps be called *twin fields*, such as physical chemistry or chemical physics, from different points of view. The appropriate attitude in such matters seems to be to avoid the artificial issue by classification and nomenclature derived from a viewpoint common to both.

In view of the historical significance of the words "physical" and "chemical," their use in classifying forces appears rather unnatural. A less artificial nomenclature is that derived from the fundamental theory of the constitution of matter common to both physics and chemistry, according to which forces are classified as (1) *molar*,* (2) *molecular*, (3) *atomic*, and (4) *electronic*. There is little anthropomorphic in these words, and they centre the attention on the phenomena. The classification is qualitative in the sense that no quantitative relations of these forces to energy have yet been defined. The electron theory of atomic structure, however, dispels much of the vagueness surrounding many of the forces, and raises into further prominence the conviction of Faraday that there is but one fundamental type of force.

Electronic forces may be defined as those which maintain the negative or valence electrons and the positive nucleus in equilibrium as a single system. Similarly, atomic forces may be defined as those which maintain two or more atoms in equilibrium as a single system; molecular forces as those which maintain two or more molecules in equilibrium as a single system; and molar forces those which maintain two or more masses in equilibrium as a single system. Each group of forces may be regarded as the residual fields of force remaining unsaturated in the smaller systems constituting the components of the system under consideration.

For the description of certain phenomena the molar theory is sufficient, but soon a stage is reached at which the phenomena must be considered in more detail. The system considered is then restricted to groups of molecules. This system is in its turn further restricted to atomic groups, and so on. The important point is that each theory includes all those preceding as special cases, as the result of simplifying approximations, or as arising from statistical considerations. The more closely one wishes to examine the nature of the extended system the more the point of view approaches that of the restricted system. The key to the nature of molecular forces, for example, is to be found in atomic considerations. This is the point particularly emphasised by Langmuir in his paper.

Whatever the nature of the fields of force, the effect of neighbouring systems would be expected to be more definite the more discrete the structure. Thus electronic forces are definitely characteristic of the nature of the element, showing the finite differences of the periodic system. Atomic forces show more continuity, only two distinct distinct types occurring, corresponding to primary and secondary valence. These may be called *primary* and *secondary* atomic forces. Molecular systems have lost so much of their discreteness that combinations of molecules do not follow the laws of definite and multiple proportions. In such phenomena as molecular association and surface structure, the discreteness of atomic constitution begins to give place to statistical continuity. Moreover, even in these phenomena, the forces are relatively so weak that molecules are not usually regarded as permanently grouped together.

In order to avoid the troublesome conflicts which are involved in the use of the words physics, physical chemistry, and chemistry, for many purposes it would be convenient to classify these portions of science into molar theory or *molics*, molecular theory or *moleculics*,† *atomics*, and *electronics*.

* Communicated by S. W. Stratton to the *Journal of the Washington Academy of Science*, ix. No. 13.

* *Molar* is derived from the Latin *moles*, a large mass. In the Century Dictionary *molar forces* are defined as those producing motions between large masses, *molecular forces* those between molecules, but which are insensible at sensible distance.

† The accent might be placed upon the penult, as in *monatomic*.

Molics deals only with continuous quantities and ideal discontinuities such as surfaces. This is the province of classical physics. In molecules the statistical nature of molar quantities must be considered. For instance, actual surfaces between distinct phases are not regarded as mathematical surfaces of discontinuity, but as possessing a molecular structure, so graphically shown by Langmuir and his predecessors. Such phenomena as molecular association, condensation, and those connected with colloids and ions in gases are also typically molecular in that finite groups of molecules are involved and the range of forces is not large compared with the distances between molecules. Moleculics thus includes much of what is often called physical-chemistry. The complexity of molecular systems limits the application of quantitative methods, in spite of the great advances in statistical mechanics.

The great fertility of the atomic theory has produced such a mass of systematic knowledge that the province of atomics is easily defined. Moreover, the definiteness and comparative simplicity of atomic systems makes classification easy. This is still more striking in the case of electronics, which perhaps may be even more productive of systematic knowledge than atomics has been. To some, attention to nomenclature is considered trivial, but early in his career Faraday remarked the importance of clever definitions which he always recorded, and demonstrated by his example the close relation between the progress of science and its nomenclature. Moreover, if the main purpose of science is economy of thought, it is as necessary to systematise and classify facts already known as to discover new facts only to have them buried unappreciated.

CHEMICAL ACTION PRODUCED BY RADIUM EMANATION. II.*

THE CHEMICAL EFFECT OF RECOIL ATOMS.

By S. C. LIND.

(Concluded from p. 66).

Addendum.

IN reporting the investigations of the foregoing Parts I. and II. it was not desired to burden the results with a discussion of a possible mechanism of reaction. The results obtained are purely experimental, and the laws governing both the rate and extent of reaction under a given set of conditions have been established, independently of the theory of the nature of the effect. Although the idea that ionisation is the primary cause of the chemical actions has been the guiding hypothesis of the writer, the other possibilities are not to be lost sight of, namely, a theory of mechanical bombardment; one of thermal effect (Debierne, *loc. cit.*), and one of electronic stress without actual ionisation.

The main argument in favour of a theory of ionisation as the primary agent has consisted in the statistical agreement for a number of reactions between actual number of ions and number of molecules reacting. For all reactions hitherto examined, except one, the agreement is within a multiplier of a few units in either direction. The one marked exception is the combination of hydrogen and chlorine, first pronounced exceptional by the writer (*Journ. Phys. Chem.*, 1912, xvi., 610), to the extent of 100—1000 fold, from data of Jorissen and Ringer for β-rays (*Ber.*, 1906, xxxix., 2093). The exceptionally high ratio of chemical action to ionisation has since been confirmed by Taylor (*Journ. Am. Chem. Soc.*, 1015, xxxvii., 24; 1916, xxxviii., 280) and Bodenstein for α-particles, and computed by Taylor to be 4000 fold for a very sensitive mixture of hydrogen and chlorine—one very low in oxygen (D. L. Chapman, *Journ. Chem. Soc.*, 1909, I., xcv, 959). Bodenstein proposed a very interesting theory in this connection not only for corpuscular radiation, but also for photochemical effect (*Zeit. Phys. Chem.*, 1913, lxxxv., 329). On account of deficiency of photochemical ionisation, the photochemical part of the theory was later abandoned (*Zeit. Elektrochem.*, 1916, xxii., 53), or rathe modified to a form which has not yet been available to the writer, but would probably fall under electronic stress. At any rate, it is clear that the hydrogen-chlorine reaction belongs in a class by itself, and cannot be considered at present with the other reactions conforming more closely to the statistical requirements of ionisation.

The approximate statistical agreement between ionisation and chemical action has been found to hold for a number of kinds of corpuscular radiation:—Cathode rays

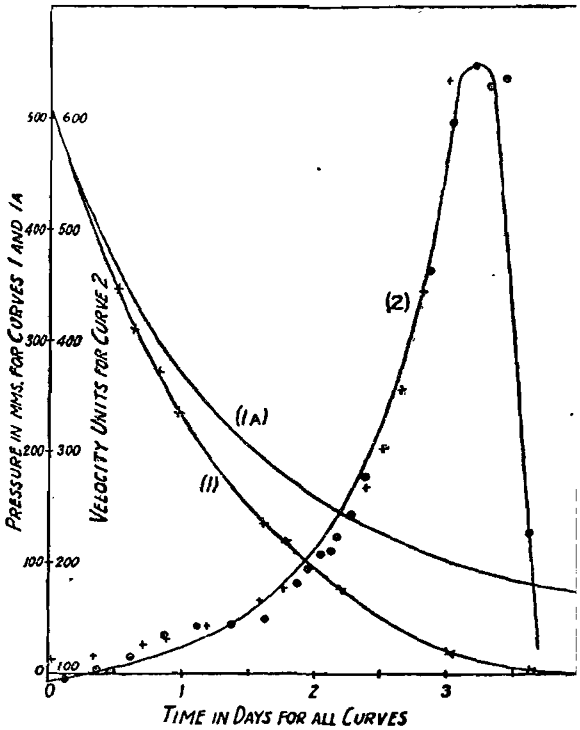

Fig. 1.

(Krueger, *loc. cit.*), β-rays (Lind, from Usher's results, *Ibid.*), α-particles (several authorities), and finally for recoil atoms (present paper). The fact that these particles differ in mass from 1/1700 to 220 times that of the hydrogen atom is very interesting.

It remains finally to see if the excess of chemical action M over the number of ions N to the extent $M_{H_2O}/N = 3.92$ for the combination of hydrogen and oxygen can be accounted for plausibly in terms of ions and their interaction. It has been shown, Part I., Section 6, that both components are activated by the α-particles in proportion to their specific ionisations. Theretore we may assume either ion activated as follows:—

$$H_2 = H_2^+ + (-) \text{ or } O_2 = O_2^+ + (-).$$

The liberated electron in either case may attach itself as follows:—

$$(-) + H_2 = H_2^- \text{ or } (-) + O_2 = O_2^-.$$

The resulting ions may react to form positively or negatively charged H_2O

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For example,—

$$H_2{+} + O_2 = H_2O_2{+} \quad \text{or} \quad O_2{+} + H_2 = H_2O_2{+},$$

or,—

$$H_2{-} + O_2 = H_2O_2{-} \quad \text{or} \quad O_2{-} + H_2 = H_2O_2{-}.$$

Assuming, then, that charged H_2O_2 reacts with H_2 to form H_2O :—$H_2O(+ \text{ or } -) + H_2 = 2H_2O$, and that the water formed loses its charge without further reaction, we should have 4 molecules of water resulting from one original pair of ions by a number of possible ways, all of which are quite plausible from our knowledge of gaseous ions. The experimental value of M/N was 3·92 (Part I., Section 8), or 3·7 according to Scheuer (*loc. cit.*). The slight deficiency below 4·0 could be accounted for by side reactions of lower efficiency, such as $H_2O_2{-} + H_2{+} = 2H_2O$, and others. The reason that these less efficient reactions do not occur to a greater extent is owing to the much smaller chance of their taking place from the standpoint of concentration and mass action.

The mechanism proposed at least shows that the ratio M/N = 4·0 is still within the limits of ionic possibilities without resorting to other theories. On assuming with Bodenstein that an electron can attach itself to activate a molecule, can be again detached by the reaction, and continue to act thus through a large number of cycles until consumed by some action from which it is not again liberated, there would be almost no limit to the multiplied activity of a single electron.

Whether ionisation is the primary step in the chemical action produced by α-particles and other corpuscular radiation or not, since it is approximately proportional to it for most reactions, it remains the most convenient means of comparative reference. The specific ionisation is either known or can be calculated for most gases, and thus at least an approximate prediction may be made of the quantity of chemical action to be expected under a given set of conditions.

THE DETERMINATION OF NITROUS ACID AND NITRITES.*

By J. S. LAIRD and T. C. SIMPSON.

In a recent article by Fox entitled "The Chemical Control of Ammonia Oxidation (*Journ. Ind. Eng. Chem.*, 1917, ix., 737) there is advocated the use of an alkaline solution of hydrogen peroxide as a reagent for the absorption and determination of nitrous gases, the excess of standard peroxide being titrated with potassium permanganate. This method is also recommended by Taylor and Davis (*Journ. Ind. Eng. Chem.*, 1917, ix., 1106), though they pointed out that according to Carpenter (*Journ. Soc. Chem. Ind.*, 1886, v., 287) the oxidation of nitrous gases by hydrogen peroxide is incomplete in alkaline solution.

In connection with some work involving a large number of determinations of nitrous acid and sodium nitrite we attempted to use this method, as it has some obvious advantages, particularly in the rapidity and sharpness with which peroxide can be titrated at ordinary temperatures. In testing the method on standard solutions we obtained very discordant results, which led to a study of the various methods suggested for the determination of nitrites. This investigation has shown that the peroxide method is inaccurate, probably on account of catalytic decomposition of the peroxide. Potassium permanganate can, however, be used as oxidising agent and made the basis of a rapid, accurate method, if used strictly in accordance with the well known principles of permanganate titration.

Preparation of Standard Solutions.

Lunge (*Ber.*, 1877, x., 1073) and Mason ("Examination of Water") recommend the use of carefully prepared silver nitrite in preparing a standard nitrite solution. Such a solution was prepared by dissolving in hot water 7·695 grms. of silver nitrite, twice recrystallised from hot water and dried in a vacuum desiccator in the dark. A slight excess of pure sodium chloride was added to precipitate the silver, and after being allowed to settle the precipitate was filtered off and carefully washed, and the filtrate and washings made up to one litre with water. The solution so prepared gave on titration with permanganate a value about 1 per cent weaker than that calculated, indicating that silver nitrite was not a reliable standard, a conclusion which has been confirmed by determinations which will be given later.

To avoid this difficulty, a solution of pure sodium nitrite was prepared, and standardised according to the gravimetric method worked out by Busvold (*Chem. Ztg.*, 1914, xxxviii., 28). 100 cc. of the solution was added to 1·5 grms. of recrystallised silver bromate dissolved in 200 cc. of normal acetic acid in a flask. 30 cc. of 1 : 4 sulphuric acid was added, and the flask was shaken and warmed to coagulate the yellow precipitate of silver bromide formed. The precipitate was filtered on a Gooch crucible, washed, and dried at 130°. The factor for conversion is 1·1022. The results of careful determinations by this method show excellent agreement and are believed to be quite accurate. Based on such determinations our solution had a concentration of 0·0977 N.

The potassium permanganate solution was prepared by dissolving 80 grms. of pure crystals in 5 litres of distilled water. The solution was boiled under a reflux condenser for two days, allowed to settle, and filtered through a Gooch crucible. It was standardised according to the method of Sorensen (*Zeit. Anal. Chem.*, 1903, xlii., 352), against a freshly prepared solution of very pure sodium oxalate. In this standardisation, as indeed throughout the whole investigation, the solutions were measured by means of standardised pipettes and weight burettes.

The hydrogen peroxide solution was prepared from Merck's 30 per cent "Perhydrol," or for part of the work, where noted, from commercial peroxide. Ferrous sulphate was dissolved in normal sulphuric acid and titrated the day used, as was also the peroxide.

The Hydrogen Peroxide Method.—Oxidation by means of peroxide was tested in both acid and alkaline solutions as follows:—25 cc. nitrite solution was run into a flask, and excess peroxide was added. The solution was then made distinctly acid with sulphuric acid or alkaline with potassium hydroxide. After permitting the reaction to go on for 5—15 minutes with frequent shaking, the excess peroxide was titrated with permanganate, after acidifying with 5—10 cc. 1 : 1 sulphuric acid.

In these titrations the end-point was never satisfactory, fading colours being produced with the addition of the last few drops of permanganate. This suggested the presence of nitrite unoxidised by the peroxide, which was confirmed by Griess' reagent even in solutions which had been boiled for ten minutes to expel the excess of peroxide. Though permanganate was used in oxidising this nitrite, less permanganate was required in titrating back than was theoretically necessary, indicating loss of peroxide, probably by catalytic decomposition. This decomposition seemed to be as great in acid as in alkaline solutions, as shown in Table I. In this table as in those which follow the volumes of solutions used are recalculated to equivalent volumes of exactly tenth normal solutions.

In these tests on an average 3·46 per cent of the hydrogen peroxide added has decomposed, and the experimental error by this method may be as much as 5 per cent.

Method of Lunge.—According to Lunge (*loc. cit.*) nitrous acid can be determined accurately by means of permanganate if the nitrite is run slowly into warm acid permanganate instead of the reverse. The reaction goes very slowly towards the end, especially if the solution is not warm enough, and it is very easy to overstep the end-point. If the solution is too warm a precipitate of man-

* From the *Journal of the American Chemical Society*, xli., No. 4.

ganese dioxide is formed which makes the end point almost impossible to determine.

TABLE I.—*Oxidation by Peroxide.*

Taken: 24·42 cc. $NaNO_2$; 48·81 cc. H_2O_2.
Calculated $KMnO_4$, 24·34 cc.

Reaction of solutions.	Required 0·1 N $KMnO_4$. Cc.	Error. Cc.
Alkaline	22·79	−1·60
	22·44	−1·95
	22·81	−1·58
Acid	23·07	−1·32
	23·04	−1·35
	22·05	−2·34

Three determinations were made by this method using in each case 16·55 cc. 0·1 N $KMnO_4$ in a volume of about 200 cc., containing 10 cc. sulphuric acid, at a temperature of 30—40° C. In the three determinations 0·28 cc., 0·25 cc., and 0·24 cc. less nitrite solution than theoretically necessary were required. It is probable that with sufficient care accurate results can be obtained by this method, but as has been pointed out by Raschig it is too slow and uncertain to be satisfactory (*Ber.*, 1905, xxxviii., 3911).

Method of Scott.—According to Scott ("Standard Method of Chemical Analysis," p. 521) nitrite can be oxidised in acid solution by excess permanganate solution, and the excess titrated back with sodium oxalate solution, the titration being carried out in hot solution, 60—90°. This is contrary to accepted practice, which demands that the permanganate be added slowly to the oxalate solution and not the reverse. In our test a precipitate of MnO_2 was formed in each case, the end-point was very uncertain, and the results most unreliable, as shown in Table II.

TABLE II.—*Method of Scott.*

No.	0·1 N $NaNO_2$. Cc.	0·1 N $KMnO_4$. Cc.	0·1 N $Na_2C_2O_4$. Cc.	Error. Cc.
1 ..	29·31	34·66	5·49	−0·14
2 ..	29·31	34·66	5·46	−0·12
3 ..	14·65	41·37	23·89	2·83
4 ..	14·65	41·37	22·45	4·27
5 ..	14·65	41·37	26·18	0·54

Method of Raschig.—The unsatisfactory nature of Lunge's method has been pointed out by Raschig (*loc. cit.*), who suggested a modification which is much more accurate. According to his method the nitrite solution is run into about 25 per cent excess neutral permanganate. After two minutes the solution is acidified, 5 cc. 10 per cent KI added to reduce the excess permanganate, and the iodine liberated titrated with sodium thiosulphate. One determination was quoted, which agreed with the theoretical to one part in 400, but no details were given as regards standardisation of the solutions. Bray and Mackay (*Journ. Am. Chem. Soc.*, 1910, xxxii., 1193) have shown that the iodine liberated from potassium iodide by permanganate standardised by sodium oxalate is 0·2—0·3 per cent too low when titrated with thiosulphate standardised against pure potassium iodide or iodine. In this laboratory it has been found almost impossible to procure potassium iodide from which iodine is not set free on acidifying. Iodine is also slowly liberated from potassium iodide in sulphuric acid solutions which contain even small amounts of nitrate such as would be formed during a determination. These errors are not large and may be determined by a blank experiment using exactly the same amount of potassium iodide solution as is used in the regular determination. But any method which requires the use of this expensive and, at the present time, almost unobtainable reagent, cannot be considered satisfactory or convenient.

Method Suggested by the Authors.—The method suggested by the authors differ from that of Raschig in using standard ferrous sulphate, sodium oxalate, or hydrogen peroxide in excess as reducing agent, the excess being titrated with standard permanganate. Excess permanganate is placed in a flask and acidified with 10—20 cc. of 1 : 4 sulphuric acid. The nitrite solution is run in slowly with constant shaking. In this way there is no danger of loss due to decomposition of the nitrite on acidifying. Dilute acid is preferable as it avoids the heating of the solution caused by addition of concentrated acid. Excess of ferrous sulphate, hydrogen peroxide, or sodium oxalate solution is then added, and the clear solution is titrated with permanganate to a faint pink. If oxalate is used, it is necessary to heat the solution. This is unnecessary when using ferrous sulphate, and in fact the solution should be kept at ordinary temperatures to avoid oxidation of ferrous sulphate by the air. The end-point is quite sharp, showing complete oxidation of the nitrite. The accuracy of the method is shown by Table III.

TABLE III.—*Method of Authors.*

Solutions all recalculated to 0·1 N.

Composition of solution.	$KMnO_4$ solution. Cc. Calcd.	Required.	Error.
24·42 cc. $NaNO_2$; 14·47 cc. $FeSO_4$	38·89	38·91	0·02
,,	,,	38·90	0·01
,,	,,	38·94	0·05
,,	,,	38·94	0·05
,,	,,	38·92	0·03
,,	,,	38·91	0·02
24·42 cc. $NaNO_2$; 28·94 cc. $FeSO_4$	53·36	53·34	−0·02
,,	,,	53·38	0·02
,,	,,	53·33	−0·03
23·52 cc. $NaNO_2$; 20·14 cc. H_2O_2	(*a*) 43·66	43·80	0·14
,,	,,	43·75	0·09
,,	,,	43·67	0·01
19·54 cc. $NaNO_2$; 11·28 cc. $Na_2C_2O_4$	30·82	30·82	0·00
,,	,,	30·75	−0·07
,,	,,	30·82	0·00
,,	,,	30·80	−0·02
,,	,,	30·77	−0·05
,,	,,	30·80	−0·02
23·52 cc. $NaNO_2$; 18·83 cc. H_2O_2	42·35	42·41	0·06
,,	,,	42·34	0·01
,,	,,	42·52	0·17 (*b*)
,,	,,	42·37	0·02
,,	,,	42·40	0·05
,,	,,	42·31	−0·04

(*a*) Acidified with HNO_3 instead of H_2SO_4.
(*b*) Solution became hot due to use of concentrated H_2SO_4 and heavy precipitate of MnO_2 formed.

There seems little difference in the accuracy of the results obtained with oxalate and ferrous sulphate; peroxide seems slightly less reliable. The use of the oxalate has the disadvantage of requiring heating of the solution, but the reagent is quite stable. Ferrous sulphate must be restandardised frequently, but is rather more stable than hydrogen peroxide. In case the use of sulphuric acid had to be avoided, as, for example, if barium were present, hydrogen peroxide could be used in nitric acid solution. The end-point in nitric acid solution is not quite so sharp, evanescent pink colours being obtained with each drop added towards the end. The results are, however, fairly accurate.

Use of Commercial Hydrogen Peroxide.—Commercial hydrogen peroxide can be used only if it is free from impurities or substances added to prevent decomposition which react slowly with permanganate. There is no reason why a solution which gives a good end-point when

titrated should not be satisfactory. This was found to be true of solutions prepared from the commercial hydrogen peroxide used in the laboratory of the University of Michigan.

Stability of Hydrogen Peroxide Solutions.—Dilute acid hydrogen peroxide solutions are fairly stable. In 1916 0·1 N solutions of peroxide in normal sulphuric and normal nitric acids were prepared and standardised by Dr. H. H. Willard of the laboratory of the University of Michigan. The solutions have since then been kept in dark glass bottles in a dark cupboard. On restandardising the results below were obtained.

Acid.	Conc. 5/15/16	Conc. 10/18/18.	P.c. decrease.
H_2SO_4	0·1189 N	0·1120 N	5·8
HNO_3	0·1291 N	0·1018 N	21·1

The sulphuric acid solution of hydrogen peroxide has decreased in strength at the rate of 0·2 per cent a month, the nitric acid solution much more rapidly. Under less favourable circumstances the decrease in strength is more rapid. During the course of these experiments a solution made up in 1 per cent sulphuric acid solution was kept in a clear glass bottle, from which samples were frequently taken. Its strength decreased in two weeks from 0·1255 N to 0·1236 N, or on the average of 0·1 per cent a day. The ferrous sulphate solution under similar conditions decreased in eighteen days from 0·1437 N to 0·1419 N, or on the average of 0·05 per cent a day. Ferrous sulphate may be made much more stable by keeping a coil of pure aluminium wire in the solution as suggested by Waring (*Mining Sci. Press*, 1918, cxvii., 193).

Determination of Nitrite in Presence of Chlorides or Bromides.—According to Busvold (*loc. cit.*) the titration of nitrites with permanganate according to the method of Lunge is inaccurate in the presence of chlorides, and he quoted results which showed that less than the theoretical amount of permanganate was required, a result quite contrary to what might be expected.

Experiments were made to determine the effect of chlorides and bromides by adding known amounts of solutions of sodium chloride or bromide to a 20 cc. sample of the nitrite solution before adding it to the permanganate, and completing the determination as usual. Results are given in Table IV. The concentration of chloride or bromide in Col. 1 are based on titrating in a volume of 150 cc.

TABLE IV.—*Effect of Chlorides and Bromides.*

In each determination 23·52 cc. 0·1 N $NaNO_2$ were taken.

Conc. chloride or bromide in solution when titrated.	0·1 N H_2O_2. Cc.	0·1 N $KMnO_4$, Cc.	Error. Cc.
N/75 NaCl ..	18·74	42·29	0·03
N/20 NaCl ..	18·74	42·30	0·04
N/4 NaCl ..	18 74	42·25	−0·01
N/4 NaCl ..	21·54 ($FeSO_4$)	45·14	0·08
N/2 NaCl ..	18·66	42·24	0·06 (*a*)
NaCl	18·74	42·58	0·32 (*b*)
N/150 NaBr ..	18 63	42·22	0·07
N/50 NaBr ..	18·63	42·62	0·47 (*c*)

(*a*) Slight odour of Cl.
(*b*) Odour of Cl, poor end-point.
(*c*) Odour of Br, poor end-point.

These results show that the titration can be carried out in the presence of chloride as long as the concentration of Cl is not over 0·5 N in the solution during titration; in the case of bromide the safe limit is very much lower, about 0·0067 N. As has been shown by Barneby (*Journ. Am. Chem. Soc.*, 1915, xxxvii., 1496), manganese salts greatly decrease the rate of reaction between chlorides or bromides and permanganate. This protective effect can be made use of in this titration when necessary. On the addition of 0·5—1·0 grm. manganese sulphate to the permanganate solution before adding the nitrite, most of the permanganate is precipitated as manganese dioxide. Under these conditions there is practically no odour of chlorine on titrating even in a 5 per cent chloride solution; or of bromine in a 0·033 N bromide solution. The end-point is fugitive, however, and as in the titration of iron under such conditions the first pink colour which spreads throughout the solution must be taken as the end-point even though it does not persist for over five seconds.

Test of Purity of Silver Nitrite.—Silver nitrite carefully prepared as above was tested for nitrite content according to this method. In some cases the pure crystals were dissolved in hot water, in others were placed directly in the permanganate. In all cases low results were obtained, indicating either that the crystals did not have the composition represented by the formula or that there is partial decomposition on solution. Lunge (*loc. cit.*), who prepared standard solutions by dissolving silver nitrite in concentrated sulphuric acid, obtained results 4 per cent too low, which he assumed to be due to partial decomposition. Some of the results obtained by us are given in Table V.

TABLE V.—*Purity of Silver Nitrite.*

Composition of solution.	0·1 N $KMnO_4$ solution (cc.). Calculated.	Required.	Error.
0·3847 grm. $AgNO_3$+15·00 cc. 0·1 N $Na_2C_2O_4$	65·00	63·95	−1·05
		62·87	−2·13
		62·66	−2·34

These results show clearly that silver nitrite is not reliable as a standard in nitrite determinations.

Summary and Conclusions.

1. The volumetric methods described in the literature for the determination of nitrous acid or nitrites are not satisfactory.

2. A method has been devised for determining nitrites which is, briefly stated, oxidation in acid solution with excess permanganate, reduction of the excess permanganate with excess ferrous sulphate, sodium oxalate, or hydrogen peroxide, and titration of the excess of reducing agent with permanganate. The titration is not interfered with by moderate amounts of chloride or small amounts of bromide.

3. Silver nitrite is not a satisfactory material for use as a standard in nitrite determinations. A satisfactory standard solution may be made by titrating sodium nitrite solution with potassium permanganate according to the method described above; or sodium nitrite solution may be standardised gravimetrically by the reduction of silver bromate to silver bromide according to the method of Busvold.

VACUUM ARC SPECTRA OF VARIOUS ELEMENTS IN THE EXTREME ULTRA-VIOLET.*

By Prof. J. C. McLENNAN, F.R.S.; D. S. AINSLIE, M.A.; and D. S. FULLER, M.A., University of Toronto.

(Continued from p. 71).

4. *Results for Metal Arcs.*

1. *Zinc.*—The results obtained for this metal below λ 2025·5 A are given in Table II. together with the results of Eder and Valenta and of Saunders (*Astrophys. Journal*, 1916, xliii., No. 3), who all used a zinc spark as source. Those obtained by Wolff by the use of a prism spectrograph and a zinc vapour arc lamp are also included in the Table. Down to λ 2025·5 A the results obtained in the present work agreed closely with those of Eder and Valenta and of Saunders. Between λ 2025 A and λ 1600 A Saunders gives a list of seventeen faint arc or spark lines, and Wolff

* From the *Proceedings of the Royal Society*, A, xcv., 316.

three arc lines, for which no corresponding values were found in this work.

TABLE II.—*Zinc Ultra violet Spectra.*

Arc spectrum.			Spark spectrum.		
Intensity.	The Authors. λ (A).	1/λ.	Wolff. λ (A).	Eder and Valenta. λ (A).	Saunders. λ (A).
16	2025·5	49 370		2025·51	2026·19
					2012·55
					1987·17
					1982·21
					1969·59
					1964·76
					1919·04
					1839·19
					1833·79
3	1821·8†	54,890			1767·84
					1757·25
					1752·6
					1749·59
					1745·73
					1742·98
					1706·89
			1649·87		1689 04
			1632·11		1673·09
			1601·09		
10	1589·6	62,909	1589·76		
1	1510·4*	66,207			
1	1491·5*	67,047			
6	1486·2	67,286	1486·20		
2	1478·5*	67,636			
4	1477·6	67,932	1476·01		
			1474·67		
4	1457·9*	68,592			
4	1457·5	68,681	1457·56		
4	1451·1	69,915	1450·82		
3	1445·0	69,204			

* Lines apparently not noted by previous observers.
† May be due to lead.

From λ 1589·6 A to the end of the region investigated our measurements cover those of Wolff, with the exception of a line at λ 1474·67 A, for which no corresponding wave-length was found in our work. A number of lines, however, were observed in this work for which no corresponding measurements were found in the lists of other observers. It is interesting to note that our results with the vacuum brought out several faint lines not secured with an ordinary vapour arc lamp such as Wolff used.

The metal employed in this work was that classed as chemically pure.

It should be noted here that there was little similarity between our list and the results given by Handke for the zinc spark ("Inaug. Diss.," Berlin, Aug., 1909).

2. *Aluminium.*—The vacuum arc spectrum for this metal was obtained by using aluminium terminals made from ordinary commercial metal. The arc obtained was of the intermittent type giving an intense source of light for the short intervals when the circuit was broken. The wave-lengths in the region investigated were well covered by those of Lyman, Handke, Eder and Valenta, and Takamine and Nitta ("Memoirs of the College of Science, Kyoto Imperial Univ.," 1917, ii., No. 2). It is interesting to note that the vacuum arc spectrum for this metal corresponded closely with its spark spectrum. Saunders also observed the same phenomenon in his work on the vacuum arc spectrum of aluminium. The measurements for this metal, together with the wave-lengths recorded by other observers for the spark spectrum below λ 2000 A are given in Table III. As might be expected from other work, the lists for the spark spectrum contain more lines than were obtained with a vacuum arc.

3. *Copper.*—The copper vacuum arc spectrum was obtained by using electrodes made of the metal itself. With a current of 9 amperes the arc was almost continuous. The results obtained in this work below λ 2037 A are given in Table IV., together with values of wave-lengths which correspond with ours, as given by Handke and by Eder and Valenta for the copper spark. Their measurements are not given in full, because they contained a great many lines which were not observed in our work. Our list, however, includes several lines not given by these investigators.

The results indicate that the relative intensities of the lines in the vacuum arc spectrum of this metal are more nearly like those of the spark spectrum than of the ordinary arc in air. In this regard our results confirm those of Saunders.

TABLE III.—*Aluminium.*

Arc spectrum.			Spark spectrum.			
Intensity.	The Authors. λ (A).	1/λ.	Lyman. λ (A).	Handke. λ (A).	Eder and Valenta.	Takamine and Nitta. λ (A) in air.
14	1989 9	50,251			1989·90	1989·8
4	1935·1	51,677			1935·29	1935·2
10	1930·4	51,803			1930·41	1930·3
32	1862·8	53,685	1862·8	1862·8	1862·20	1862·1
						1861·5
			1858·2	1858·2	1857·56	1857·4
						1855·3
32	1854·5	53,918	1854·7	1854·7	1854·09	1854·0
				1836·8		
				1833 2		
				1820·6		
			1818·5	1819·6		
				1819·0		
				1792·1		
				1777·8		
			1776·9	1777·1		
				1774·9		
			1773·8	1773·8		
				1772·9		
				1769·6		
			1767·7	1768·0		
			1765·7	1766·9		
4	1766·6	56,606		1766·0		
			1763·8	1764·2		
10	1761·9	56,754	1761·9	1762·4		
			1760·0	1760·4		
			1751·7	1752·1		
			1750·0	1750·4		
			1747·7	1748·3		
			1745·3	1746·3		
			1742·7	1743·6		
10	1724·3	57,995	1725·0	1725·3		
8	1720·7	58,116	1721·2	1722·0		
4	1718·5	58,190	1719·3	1720·0		
			1718·3	1719·1		
				1676·1		
4	1670·6*	59,859	1670·6	1671·0		
14	1611·8*	62,046	1611·8	1612·1		
12	1605·6*	62,282	1605·6	1605·9		
			1540·1			

* Used as standard lines.

(To be continued).

NATIONAL HEALTH WEEK.—We understand that it has been decided to hold the first post war National Health Week in May, 1920. Previous to the war, the celebrations in connection with this week both in the metropolis and in the various local centres throughout the kingdom served to focus public opinion and sentiment on those aspects of personal and public hygiene which are more directly the province of the man in the street and the woman in the home than of the medical and sanitary authorities. We think it is not making too great a claim to state that the pioneer work done by the Health Week Committee was one of many like factors in establishing the need for the newly formed Ministry of Health.

HOW THE NITROGEN PROBLEM HAS BEEN SOLVED.*

By HENRY JERMAIN MAUDE CREIGHTON, Department of Chemistry, Swarthmore College, Member of the Institute.

(This important communication is inserted by the kind permission of the author).

Introduction.

The enormous quantities of nitric acid and ammonia employed in the chemical industries and the nitrates used in agriculture were, until recently, obtained solely from the nitrate deposits in Chili, and from the destructive distillation of coal, these being the chief sources of inorganic nitrogen compounds. The world's total production of ammonia, calculated as ammonium sulphate, is one and one-half million tons per annnm, while the present annual production of sodium nitrate is 3,120,000 tons.

In view of the ever-increasing demand for Chili saltpetre, some years ago estimates were made of the probable life of the Chilian deposits, and while these estimates vary considerably it is evident that in a relatively short time the deposits will be exhausted. In addition to the nitrate beds in Chili, other deposits have been found in California, South-Eastern Oregon, and in the Argentine, but the amount is either not very large or the deposits are situated in localities not easily accessible.

For some time there has been recognised the necessity of obtaining inorganic nitrogen compounds from other sources than those mentioned above. This necessity has been emphasised by the recent war. Attention naturally turned to the atmosphere, which has been estimated to contain four quadrillion tons of nitrogen, or twenty million tons over every square mile of the earth's surface. Unfortunately, however, before this inexhaustible supply of nitrogen can be used for industrial or agricultural purposes it must first be converted into nitric acid, nitrates, or ammonium compounds, forms in which nitrogen is most readily utilised.

During the past few years much important research has been carried out on the transformation of atmospheric nitrogen into these forms—on the fixation of atmospheric nitrogen—and owing to the very fruitful results that have attended these labours the practical solution of the nitrogen problem may be considered achieved. These investigations have led to the development of five different methods which may be broadly classed as follows :—

I. The direct oxidation of nitrogen to its oxides with subsequent formation of nitric acid or nitrates, as exemplified in the arc processes.
II. The direct combination of nitrogen with hydrogen to form ammonia, as typified by the Haber process.
III. The absorption of nitrogen by carbides, as developed in the cyanamide process.
IV. The absorption of nitrogen by metals in the form of nitrides, as represented by the Serpek process.
V. The conversion of nitrogen into cyanides, as set forth in the Bucher processes.

At the present time the first three of these methods are successfully operated on a commercial basis. While, as yet, the Bucher process has scarcely passed beyond the experimental stage, it has been claimed that if the mechanical difficulties can be solved ammonia will be produced more cheaply by this process than by either the Haber or cyanamide processes.

The importance of these methods of nitrogen fixation in times of war, when the supply of Chili saltpetre may be cut off, is shown by the fact that Germany in 1914 produced 60,000 tons of nitric acid, in 1916 300,000 tons, and in 1917 320,000 tons from atmospheric nitrogen.

* From the *Journal of the Franklin Institute*, April, May, and June, 1919.

I. Arc Processes.

Outline of the Principles Underlying the Formation of Nitric Acid from Atmospheric Nitrogen.

The conversion of atmospheric nitrogen into nitric acid is made up of several steps, which may be expressed by the following equ ations :—

$$1.\quad N_2+O_2 \rightleftarrows 2NO.$$

$$2.\quad 2NO+O_2 \rightleftarrows 2NO_2.$$

$$3.\quad 2NO_2+H_2O \rightleftarrows HNO_3+HNO_2.$$

Since, in the presence of oxygen, nitrous acid is rapidly oxidised to nitric acid we may write :—

$$4.\quad 4NO_2+O_2+2H_2O = 4HNO_3.$$

If instead of treating nitrogen peroxide with water it is brought into contact with an aqueous solution of an alkali, nitrates and nitrites are formed.

The transformation of atmospheric nitrogen to nitric acid is by no means as simple as might appear from the above equations. The oxidation of nitric oxide to nitrogen peroxide is a reversible change, above 140° C., the latter commences to decompose into nitric oxide and oxygen, and this dissociation increases with rise in temperature until, at 620° C., it is practically complete. Therefore, between these two temperatures the gas mixture consists of nitric oxide, nitrogen peroxide, oxygen, and nitrogen (from the air). Since an equimolar mixture of the two oxides of nitrogen behaves towards aqueous solutions of alkali as if it were pure nitrogen trioxide, it is possible under proper conditions with these two gases to produce practically pure nitrite in accordance with the equation :—

$$5.\quad N_2O_3+2NaOH = 2NaNO_2+H_2O.$$

Many difficulties have been encountered in the oxidation of atmospheric nitrogen to nitric oxide. It has ben found extremely difficult to obtain profitable yields of the oxide on passing an electric discharge through air owing to the fact that the reaction expressed by Equation 1 is reversible, and that, at even moderately high temperatures, the position of equilibrium is such that only small quantities of the oxide are formed. Since the formation of nitric oxide from its elements is an highly endothermic reaction (at ordinary temperature the formation of two moles of nitric oxide is accompanied by the absorption of 43,200 grm.-calories), it follows in accordance with Le Chatelier's law that with rise in temperature the position of the equilibrium of the reaction will be displaced in the direction which favours the formation of the oxide. Starting with a given nitrogen-oxygen mixture the concentration of nitric oxide present at equilibrium will be greater the higher the temperature. From a study of the reaction at lower temperatures the concentrations of nitric oxide which would be present in the equilibrium mixture at higher temperatures have been calculated, and the values thus obtained have been found to be in good agreement with those determined by experiment, as shown by the data contained in Table I.

Table I.

Temperature °C.	Volume per cent of NO in equilibrium mixture. Observed.	Calculated.
1538	0·37	0·35
1604	0·42	0·43
1760	0·64	0·67
1922	0·97	0·98
2307	2·05	2·02
2402	2·23	2·35
2627	—	3·18
2927	—	4·39

The close agreement between the two sets of values in Table I. is a strong argument in favour of the reaction

being a purely thermal one, although evidence has been brought forward which supports the view that temperature is not the only factor which influences the reaction.

Since the velocity of all chemical reactions increases with temperature, it is evident that in order to produce nitric oxide successfully from nitrogen and oxygen it will be necessary to work, not only at a temperature at which an appreciable amount is formed, but also at a temperature at which its formation takes place rapidly. The influence of temperature on the velocity of the formation of nitric oxide is illustrated by the data contained in Table II.

The values in the last column of Table II. show that while at even as high a temperature as 1227° C. the rate of formation of nitric oxide from its constituents is so slow as to be negligible, it is produced instantaneously at temperatures above 2227° C. On the other hand, the times required for the *decomposition* of one-half of a given quantity of nitric oxide are 7.35×10^3 minutes at 627° C., 5.80×10^2 minutes at 827° C., 3.30 minutes at 1227° C., and 1.21×10^{-3} minutes at 1827° C. It is evident from these figures that at temperatures below 827° C. the rate of decomposition of nitric oxide into its constituents is so slow as to be negligible in practice.

From the preceding data, it is obvious that a very high temperature is essential for the formation of nitric oxide in even moderately small quantities. The most convenient means of producing this high temperature is the electric arc, and this is the only method which thus far has met with success. Moreover, although it has been assumed that the efficacy of the electric arc is due to its high temperature, still the observations of a number of investigators indicate the probability of purely electrical influences playing a part in the formation of nitric oxide in the electric discharge.

Table II.

Temp. ° C.	Time required for the formation of one-half the theoretical nitric oxide concentration at atmospheric pressure. Minutes.	
1227	1.81×10^3	(1.26 days)
1427	5.90×10	
1627	2.08	
1827	8.43×10^{-2}	(5.06 seconds
2027	3.75×10^{-3}	
2227	1.77×10^{-4}	(0.01 second)
2427	8.75×10^{-5}	
2627	5.75×10^{-6}	(0.000035 second)
2827	3.10×10^{-8}	

At any rate, whatever be the action of the arc, even under the most favourable conditions only a few per cent of nitric oxide is produced when equilibrium sets in. Consequently, in order to convert large quantities of nitrogen and oxygen into nitric oxide, it is necessary to remove the latter from the sphere of the action of the arc as fast as it is formed. In this way the attainment of equilibrium is prevented and the process becomes continuous. Since, as has just been pointed out, the rate of decomposition of nitric oxide into its constituents is very rapid at high temperatures, and negligibly slow for all practical purposes at temperatures below 827° C., it is necessary to quickly and efficiently cool the gas mixture after removing it from the action of the arc, in order to preserve a high concentration of the oxide. The more rapid the cooling, the less the decomposition of the oxide formed at the high temperature of the arc. An idea of the temperature of the gas mixture in the arc may be gained from the fact that, with high tension arcs, concentrations of nitric oxide as high as eight volume per cent have been obtained. This concentration corresponds to a temperature of 3700° C.

(To be continued).

BOARD OF TRADE ANNOUNCEMENT.

Exports to Poland.

The Board of Trade announce that the Supreme Economic Council in Paris have decided to withdraw the Relief Mission in September, and that in consequence the British Relief Administration will not now be remaining in Danzic for any length of time.

In these circumstances it is advisable that traders should proceed without delay to make their own arrangements for the forwarding of goods to Poland, although for the time being they may continue to consign them to the Relief Administration. They are, however, no longer required to do so.

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THE CHEMICAL NEWS.

VOL. CXIX., No. 3097.

HOW THE NITROGEN PROBLEM HAS BEEN SOLVED.*

By HENRY JERMAIN MAUDE CREIGHTON, Department of Chemistry, Swarthmore College, Member of the Institute.

(Continued from p. 83.

MANY investigations have been carried out for the purpose of increasing the concentration of the nitric oxide formed in the arc, and it has been found that this is influenced by the rate of flow of the nitrogen and oxygen through the arc, and by the proportion of these elements in the initial gas mixture. Thus Grau and Russ, using high tension arcs, found that with a high velocity of flow of the gases through the arc the concentration of nitric oxide formed was small, while with diminishing velocity the concentration increased. These investigators found, when operating at 2300—2600 volts and 175 watts, that the nitric oxide concentration produced was 2·90 volume per cent when the flow of air through the arc was 104·1 litres per hour, and 4·181 volume per cent when the flow was reduced to 30·9 litres per hour. The equilibrium concentration of nitric oxide in the arc was calculated by extrapolation for zero velocity. This gave 5·5 volume per cent from air, and 6·6 volume per cent from a mixture containing equal volumes of nitrogen and oxygen, these quantities being independent of the length of the arc. The nitric oxide concentration may also be increased by allowing the air after passing through the arc to mix with the unarced gas. It has been suggested that these conditions are favourable to the formation of ozone, and that it is the oxidation of the nitrogen by the ozone that brings about an increase in the oxide concentration.

After the formation of nitric oxide in the arc, the next step in the production of nitric acid is its oxidation to nitrogen peroxide. This may be brought about by the oxygen contained in the air which escaped combustio the arc. Since nitrogen peroxide, as already pointed o commences to break up into nitric oxide and oxygen at 140° C., and is completely dissociated at or above 640° C., it is evident that until the temperature of the gas mixture, after removal from the arc, falls below the latter temperature, no peroxide will be formed; and until the temperature is reduced below 140° C., the gas mixture will contain both oxides of nitrogen. If the cooled gas mixture is passed into water the nitrogen peroxide is converted into nitric and nitrous acids, in accordance with the reaction expressed in Equation 3. As the nitrous acids readily change into nitric acid—

$$5.\ 3HNO_2 \rightleftarrows HNO_3 + 2NO + H_2O,$$

the total reaction may be expressed by the Equation—

$$6.\ 3NO_2 + H_2O \rightleftarrows 2HNO_3 + NO.$$

Since the reactions expressed by Equations 3 and 5 are reversible, the equilibrium of the latter and, therefore, that of the former is distributed by the subsequent oxidation of the nitric oxide liberated in (5), *i.e.*,

$$7.\ 2NO + O_2 \rightleftarrows 2NO_2,$$

and, consequently, a given quantity of nitrogen peroxide must be ultimately transformed into nitric acid.

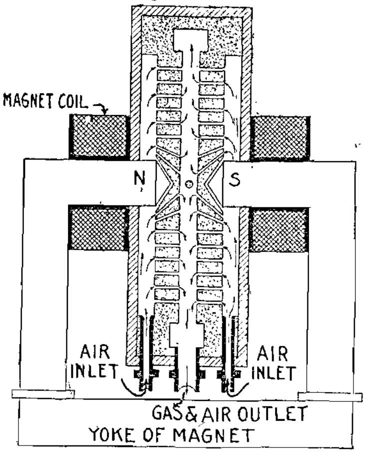
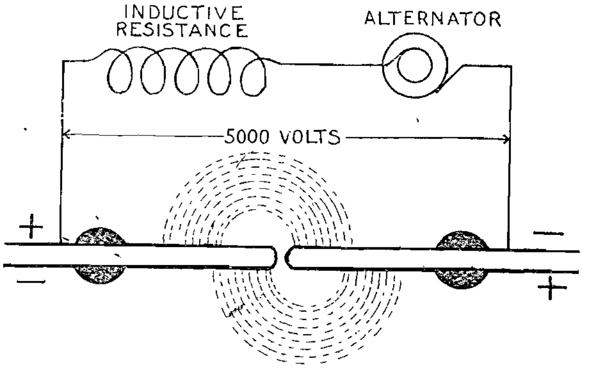


FIG. 1.—BIRKELAND-EYDE FURNACE.



DIAGRAMMATICAL REPRESENTATION OF THE DISPLACEMENT OF THE SEMICIRCULAR ARCS IN BIRKELAND-EYDE FURNACE.

FIG 2.

When a mixture of nitrogen peroxide and oxygen is led into water, nitric acid is formed rapidly until its concentration reaches about 40 per cent; the absorption then gradually becomes slower until a concentration of 50 per cent is attainted, above which the rate of absorption rapidly diminishes. The concentrations of nitric acid obtained at ordinary temperatures from gas mixtures containing different quantities of nitrogen peroxide are as follows: —

Concentration of nitrogen peroxide. Volume per cent.	Limiting concentration of nitric acid obtained. Per cent.
1	ca 46
2	ca 52
5	55

Since, technically, the cooled gases from the arc usually contain from 1—2 per cent of nitrogen peroxide, it should be possible to produce aqueous nitric acid having a concentration of about 50 per cent by treating the gas mixtur

* From the *Journal of the Franklin Institute*, April, May, and June, 1919.

with water. If, as previously mentioned, the hot gas mixture, containing both nitric oxide and nitrogen peroxide, is treated with an aqueous alkali solution, the nitrate and the nitrite of the alkali metal will be formed, the latter predominating the higher the temperature at which absorption takes place.

A few figures regarding the consumption of electrical energy in the production of nitric acid by the arc process may be of interest. Haber has calculated that the theoretical yield of nitric acid is 134 grms. per kilowatt hour, or 1174 kilogrms. per kilowatt year, at 4200° C., and 93·5 grms. per kilowatt hour or 819 kilogrms per kilowatt year at 3200° C. While the yield of acid is

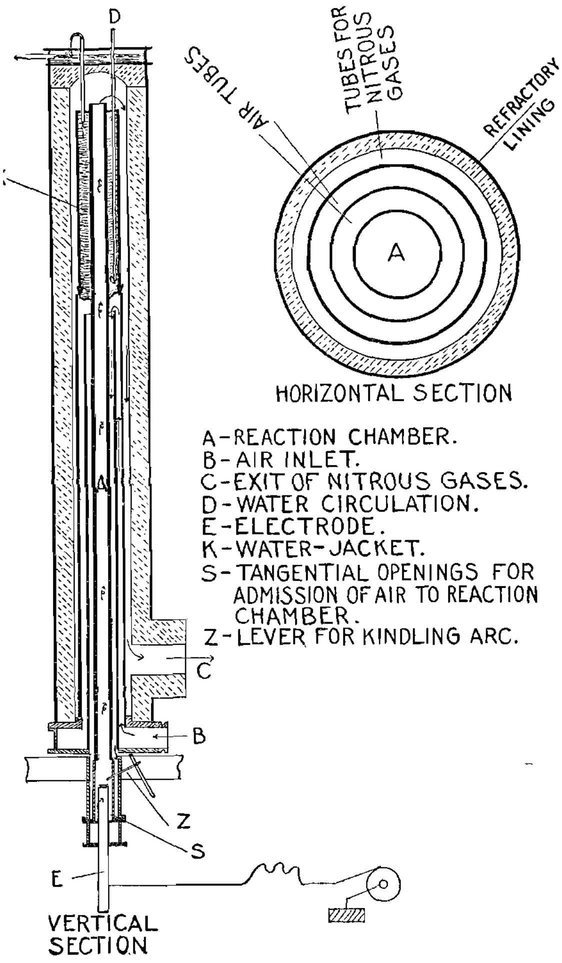


Fig 3.—Schönherr Furnace.

smaller at the lower temperature, it must be remembered that in practice there is a smaller loss of nitric oxide due to decomposition during the period of cooling, and a smaller loss of heat by radiation. Technical yields of nitric acid are always less than those indicated by the above figures.

On account of the small yields of nitric acid in the arc process, cheap power must be available in order to produce the acid profitably by the method that has been outlined; and it is chiefly in Norway and the Alpine countries, where there are large quantities of cheap water power, that, up to the present, atmospheric nitrogen has been converted into nitric acid on a commercially successful scale by the arc process. Assuming that one kilogrm. of combined nitrogen has a market value of 25 cents, then on the basis of electric power at the rate of 10 dols. per kilowatt year, a technical yield of 60 grms. of nitric acid per kilowatt hour pays for the power three times over. The variation in the cost of water power in a number of different localities is shown by the data (C. E. Lucke, *Electrochem. and Met. Ind.*, 1907, vi., 230) given in Table III. (the asterisk denotes prices at which the power is actually sold).

Table III.

Locality.	Total costs or charges per killowatt year to large consumers. (Dols.).
Niagara*	22 40—26 60
Niagara (Ontario Power Co. to Municipalities)*	13.60
Saulte Ste. Marie*	13·30
Cameron Rapids, Ontario	11 00
Kootenay Power Co.	32 00
Kanawa Falls, Virginia	12 80
Svaelgfos, Norway	2 64
Notodden, Norway	4·33
Sweden	4.16—9.60
Austria (Meran)*	15 20
Savoy (Bellegrade)*	14 10
Savoy (Chedde)	5·87

With respect to the power which is being developed at Muscle Shoals, Tennessee, United States Army engineers have placed the cost between 9 dols. and 12 dols. per kilowatt year, or about 1·5 mills per kilowatt hour.

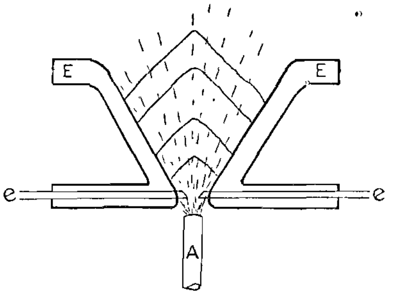


Fig. 4.—Electrodes of Pauling Furnace.

Another source of cheap electrical power is off-peak power, which, it has recently been claimed, can be secured in many places in the United States at a lower cost than Norwegian power (C. P. Steinmetz *et al*, *Proc. Am. Inst. Elec. Eng.*, 1918, advance copy).

Technical Furnaces for the Production of Nitric Oxide from Air.

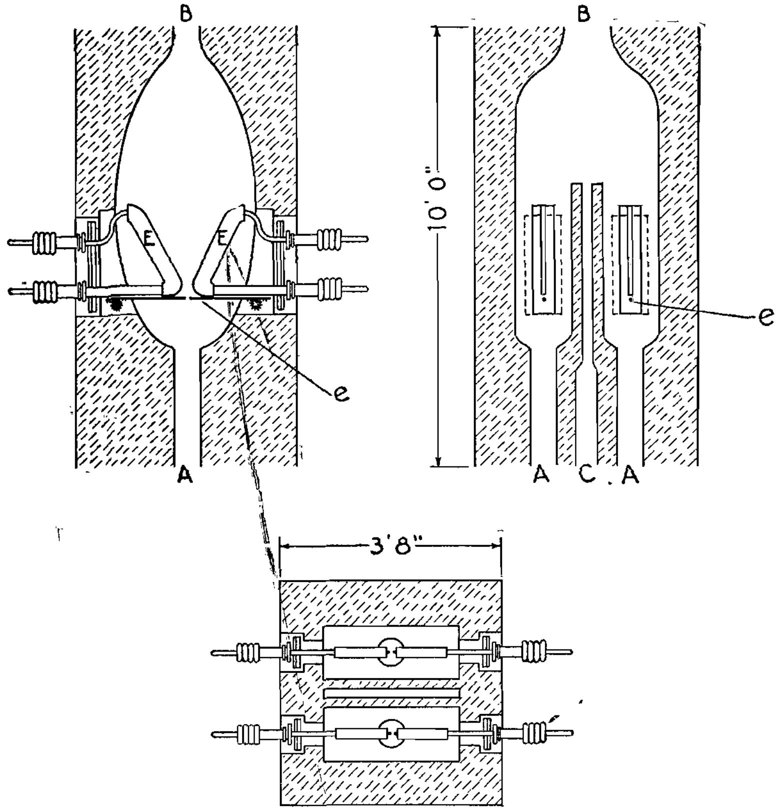
Of the different furnaces that have been devised for the oxidation of nitrogen in the electric arc only a few have been successful. Of the latter the most important are the Birkeland-Eyde furnace, which is used in Norway, France, and Spain; the Schönherr furnace, which is employed in Norway and Germany; and the Pauling furnace, which is operated in Italy, Austria, and Germany. In addition to these, the Moscicki and the Kilburn Scott furnaces should be mentioned.

(a) *The Birkeland-Eyde Furnace.*—The Birkeland-Eyde furnace, a vertical section of which is shown in Fig. 1, has the appearance of a large cylinder resting on its side between the poles of a huge electro-magnet. This cylinder is made of two similar halves of heavy cast-iron plates which are bolted together. The interior of the furnace is lined with refractory material perforated with numerous small openings through which the air enters the narrow,

circular reaction chamber situated in the centre. A peripheral channel in the casting of the furnace serves to carry away the nitrous gases from the reaction chamber. The large terminal poles of the electro-magnet are bevelled and are embedded in the lining of the furnace. The coils of the magnet, placed immediately outside of the iron shell, are fed by a direct current and absorb 0·35 to 1 per cent of the total furnace load. The thick, water-cooled tubular, copper electrodes, supported on ball insulators, enter the reaction chamber through opposite sides of the furnace, their internal ends being separated by a distance of one centimetre. The cooling effect of the 1000° C., while the temperature of the refractory lining seldom exceeds 700° C., due to the cooling effect of the air current.

The capacity of the Birkeland-Eyde furnace has increased from 300 kilowatts in 1906 to 4000 kilowatts at the present time.

The most striking features of this furnace are its simplicity and durability. It burns for weeks with scarcely any regulation. It is only necessary to change the electrodes every three or four weeks and the refractory lining every four to six months. A few workmen are able to operate a large number of these furnaces.



VERTICAL AND HORIZONTAL SECTIONS OF THE PAULING FURNACE.

Fig. 5.

electrodes causes a loss of only about 7·5 per cent of the electrical energy.

The positions of the electrodes and the poles of the magnet are such that the magnetic field is perpendicular to that of the arc. The arc is maintained by an alternating current of about 5000 volts and 50 periods per second, and is forced by the magnetic field into two semi-circular discs of flame (Fig. 2) which alternately rise and break in the lower and upper half of the reaction chamber, producing what appears to be a thin, circular sheet of flame 1·8 metres in diameter that burns with great steadiness.

The air on entering the reaction chamber impinges on the flame at right angles, where it is partially oxidised to nitric oxide. Notwithstanding the very high temperature of the arc (over 3000° C.), that of the nitrous gases on leaving the reaction chamber is between 800° C. and

(b) *The Schönherr Furnace.*—This furnace differs in principle from the one just described, in that, in place of the circular sheet of flame, a long slender arc is developed in the narrow axis of an iron tube, through which a current of air is forced. The arc is stabilised by imparting a whirling motion to the air. In this furnace the air passes along and surrounds the arc with which it is in contact for an appreciable time, whereas in the Birkeland-Eyde and Pauling (described below) furnaces the air, entering at right angles to the electric discharge, is in contact with the arc for an exceedingly short time.

The Schönherr furnace, cross-sections of which are shown in Fig. 3, consists of a vertical cylinder of iron plate, 23 feet in height, lined with refractory material. In the centre are placed three concentric wrought iron tubes. The inner tube, A, is six inches or less in diameter and constitutes the reaction chamber. The other tubes form

passages through which the air enters and through which the nitrous gases pass from the reaction chamber after being in contact with the arc. By means of this arrangement a large portion of the heat of the out-going gases is transferred to the in-coming air. The path traversed by the gases is indicated by the arrows in Fig. 3. The air enters the reaction chamber through a number of tangential openings so arranged at its base that there is imparted to it a pronounced vortical motion. This motion is sufficiently strong to maintain a material difference in pressure between the axis of the vortex occupied by the arc and the outer sections of the air current. The admission of the air to the reaction chamber is controlled by a lever. The upper third of the reaction chamber is surrounded by a water-jacket, K. The nitrous gases leave the reaction chamber at a temperature of about 1200° C., and on passing through the furnace transmit to the incoming air sufficient heat to raise its temperature to about 500° C.

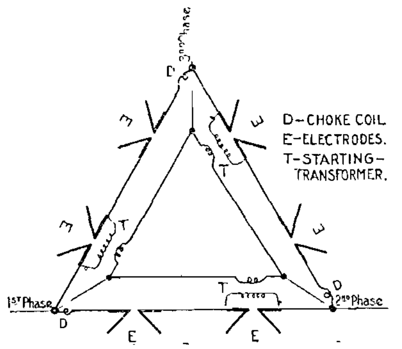


Fig 6. Pauling Electrodes in Series on each Phase.

An iron bar, E, situated at the lower end of the reaction chamber, serves as the main electrode. This bar is movable in a vertical direction through an opening in the hollow, water-cooled, copper terminal of the electric current. This electrode projects a little above the surface of the terminal, and is so arranged that it can be moved upwards by a cog mechanism as it is worn away by the action of the arc. The rate of wear is about twenty millimetres daily. The reaction chamber, in direct connection with the other metallic parts of the furnace, serves as the second electrode. The lever *z* is used to start the arc, which when once kindled is rapidly drawn upwards by the air current, the vertical motion of which maintains a slender, rod-like flame which occupies the axis of the reaction chamber throughout its length. The flame only comes in with the reaction chamber at its upper extremity which is cooled by the top portion of the water-jacket, K.

Owing to the fact that the length of the reaction chamber is governed by the voltage, and also that there is a limit to the current that can be dealt with by a single electrode, the capacity of the Schönherr furnace is restricted to 1000 kilowatts.

The Schönherr furnace requires considerable attention on account of the frequency with which the arc is extinguished, rekindling having to be done by hand.

(c) *The Pauling Furnace.*—In the Pauling furnace the arc is formed between hollow, water-cooled electrodes, E (Fig. 4), set at an angle of about 80°, and which, at their lowest point, are slightly over one and one-half inches apart, so as not to interfere with the air blast from the supply pipe, A. Very thin kindling blades, *e*, passing

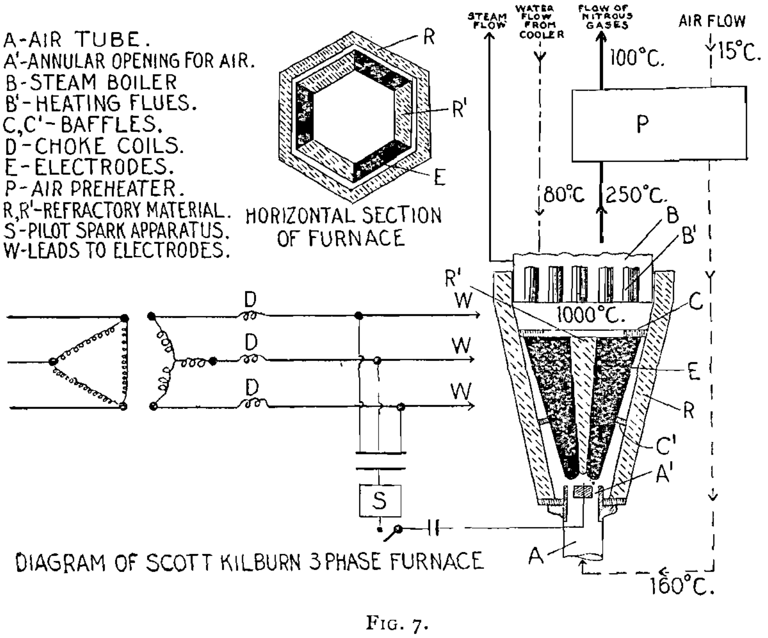


Fig. 7.

through the curved part of the main electrodes, are employed to start the arc, which is maintained with a high tension alternating current. As soon as the arc is formed it is forced by the air blast from A upwards along the inclined electrodes. At each half period a new arc is kindled, so that, with rapid alternations of the current, a sheet of flame is produced which fills the space between the electrodes and projects above them, often attaining a height of three feet.

The wrought-iron, refractory-lined furnace (Fig. 5) which is rectangular in shape with a cross section o 3·8×4 feet and a height of 10 feet, contains two sets o

electrodes arranged in series. Air enters beneath each set of electrodes through the inlets A, while the nitrous gases leave through the common outlet B. A portion of the nitrous gases from the furnace is switched off and returned through the hollow dividing wall C, after being cooled down to the proper temperature. This gas enters the upper portion of the furnace, where it rapidly cools the nitrous gases from the arcs without diluting them.

One furnace with two arcs in series is placed in each leg of a three-phase current supply. Since a much higher E.M.F. is required for kindling an arc than for its maintenance when once kindled, a transformer (T, Fig. 6) producing an ancillary current of high E.M.F., but of low power, is connected across one pair of electrodes of each series. The high tension coil of this transformer gives an E.M.F. which is several times greater than that of the main supply, so that the current which is shunted through the primary induces a voltage sufficiently high to kindle the arc. By means of an ingenious switching device the ancillary current comes into play when high tension is required for kindling the arcs, but is shut off when the main circuit is completed through the sheets of electric flame which develop between the furnace electrodes. If an arc is accidentally extinguished the secondary current is automatically switched on.

(d) *The Kilburn Scott Furnace.*—Before concluding the consideration of different types of arc furnaces, a brief description should be included of the Kilburn Scott furnace, as it has the advantages of simplicity, conservation of heat, low first and maintenance costs, and a relatively good yield of nitric oxide.

This furnace, which is shown diagramatically in Fig. 7, employs three wedge-shaped electrodes, E, spaced 120° apart, having their sides inclined towards each other 30° from the vertical, and arranged with intervening refractory material, R′, so as to form a six-sided conical space with the apex at the bottom. Each electrode is connected through inductance to one leg of a 12000 volt three-phase circuit.

The air enters the bottom of the furnace directly beneath the electrodes through the annular opening A, and is prevented from escaping without passing through the arc by the baffles, C and C′. With a three-phase current of 60 periods, a combined arc consisting of 360 separate flames per second is flared out by the air current into what appears as a double cone having one apex at the bottom and the other at the top. High frequency "pilot" sparks from the apparatus (S) serve to break down the dielectric resistance and allow the main current to arc between the electrodes.

A tubular boiler, B, with heating flues, B′, placed directly above the arc and through which the nitrous gases from the furnace pass, cools these gases from about 1000° C. to 250° C. and utilises the waste heat.

(To be continued).

PREPARATION OF HYDROBROMIC ACID, USING POTASSIUM BROMIDE, SULPHURIC ACID, AND STANNOUS CHLORIDE.

By ALWYN PICKLES, B.Sc.

In general, hydrobromic acid is not obtainable in a pure state by the action of concentrated H_2SO_4 on a bromide. If, however, the solution of the bromide be saturated and the sulphuric acid of sp. gr. 1·41, pure hydrobromic acid may be distilled off (*Pharm. Soc. Journ.*, 1891). The reaction between potassium bromide and sulphuric acid was studied after adding a little stannous chloride to the system. The potassium bromide solution was 90 grms. in 150 cc. of solution. To 25 cc. of this solution 3·4 cc. of concentrated H_2SO_4 were added, after first adding 0·2 grm. of stannous chloride to the bromide solution. The amount of acid added is approximately theoretical, according to equation $2KBr + H_2SO_4 = 2HBr + K_2SO_4$. No evolution of bromine took place, and on distillation at 120—127° a solution of HBr was obtained almost free from HCl and equal to a 95 per cent yield. The solution was free from any tin compound.

A similar experiment, stannous chloride absent, gave a smaller yield of acid and also some free bromine.

Experiments, using excess sulphuric acid, proved conclusively that stannous chloride prevents the decomposition of the hydrobromic acid in presence of excess sulphuric acid.

If the stannous chloride is used in quantities larger than 0·2 grm. the action becomes very vigorous and hydrochloric acid is present in the distillate. Further, such distillate on standing deposits a white basic tin compound.

Many salts of tin are capable of forming complex additional compounds, and no doubt such combination takes place between the $SnCl_2$ and the excess H_2SO_4, provided such excess is within limits. The presence of the white deposit in some of the distillates points to the presence of stannous or stannic sulphates, both of which compounds deposit basic compounds on standing if water is present. It is possible that the action is much more complex, especially as a small quantity of $SnCl_2$ prevented decomposition of the HBr in presence of excess sulphuric acid.

THE TECHNICAL ANALYSIS OF MERCURY ORE.

By ROY FRANKLIN HEATH.

A reliable, accurate, and rapid method for the determination of metallic mercury in cinnabar, amalgam, kleinite, and metacinnabarite or other compounds can be accomplished with the mercury assay crucible illustrated in Fig. 1.

The crucible proper has a wide shaped flat bottom, the body of which tapers to the centre. The body of the

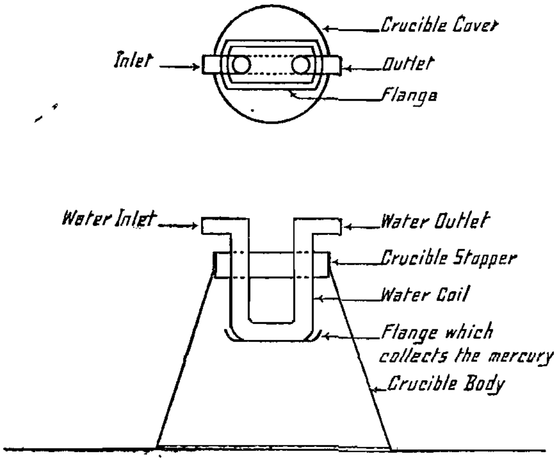


Fig. 1.

crucible is made of candia-alloy or platinum plated nickel ware. The cover, water coil, and flange is constructed of rolled gold. The cover exactly fits into the neck of the crucible body. The diagram (Fig. 1) of the crucible and cover inserted is self-explanatory.

The manipulation of the apparatus is as follows:— After mixing and inserting the assay charge into the crucible, heat for a few minutes to drive off most of the moisture, but do not heat sufficiently to volatilise mer-

curv. Do not let the mixture cake. When moisture is expelled place cover in position, connect one of the openings with tubing to flowing water, using the other opening as outlet for the water. Heat crucible to redness, slowly at first, then with increasing temperature, at the same time keeping the cover nearly cool with flowing water. Keep at near red heat for three minutes, remove heat and water, let cool to room temperature, blow excess of water from coil, dry cover in the desiccator, weigh, dissolve mercury in dilute nitric acid, wash thoroughly, dry, re-weigh, the loss of weight being the amount of mercury present.

One to 5 grms. of the crude ore or compound is used as sample depending upon the quantity of mercury present. The sample should be finely divided and mixed with double its quantity of dehydrated potassium or sodium hydroxide containing 2 per cent of sodium chloride.

THE DISTRIBUTION OF ENERGY IN THE SPECTRUM OF ERBIUM OXIDE.*

By W. S. MALLORY.

[THE following note, which forms part of a paper appearing in the *Physical Review* for July last, is of considerable interest, and it touches closely upon a communication made to the Royal Society by Sir William Crookes in 1886, entitled "Note on the Spectra of Erbia." The connection between the emission spectra of the rare earths and that given by their oxides and sulphates under cathode discharge *in vacuo* has never been fully investigated, and Mr. Mallory's observations will be found valuable to whoever undertakes this interesting investigation].

Introduction.

IT was discovered in 1864 by Bunsen (*Liebig's Ann.*, 1864, cxxxi., 255) that didymium when heated to incandescence did not give the continuous spectrum commonly seen when solids are heated, but a spectrum consisting of bright bands, superimposed upon a relatively weak continuous spectrum. The same phenomenon was discovered in the case of erbium by Bahr in 1865 (*Liebig's Ann.*, 1865, cxxxv., 376). Neodymium, holmium, and perhaps a few other rare earths have been found to give the banded spectra, although in a lesser degree. Another peculiarity in the case of these substances lies in the fact that their absorption spectra consist of a great number of very narrow bands. In some cases these absorption bands may very properly be spoken of as lines. The narrow banded absorption spectra are characteristic of these rare earths, both in solution and in the solid condition.

The present investigation was undertaken in part to determine, if possible, whether the peculiar emission spectrum of erbium oxide, when heated to incandescence, is a purely thermal radiation, as indicated by the excellent agreement, at the same temperature, in the position of the emission and the absorption bands, or whether it might not be a case of luminescence, excited perhaps by the short wave-lengths of the flame used for heating the specimen under observation.

Another purpose was to determine for different wave-lengths the relation between the intensity of the radiation from the oxide, and the intensity of the radiation from a black body at the same temperature.

I later made an approximate determination of the temperature at which the radiation in the region of the green band of the emission spectrum had the same intensity as the corresponding radiation from a black body at 1000° C.

* A good summary of the work that has been done on the spectra of the rare earths may be found in an article in the *Astrophysical Journal* of September, 1907, "The Absorption and Emission Spectra of Neodymium and Erbium Compounds," by J. A. Anderson. From the *Physical Review*, xiv., No. 1.

Some Preliminary Observations.

In preparation for the investigation it seemed best to repeat a number of experiments upon which others have reported. The results were briefly as follows:—

1. *The Emission Spectrum not a Flame Spectrum.*—Some erbium oxide powder was placed upon a small piece of quartz and heated in the Bunsen flame. The powder was directly opposite the middle of the slit of a spectrometer. Sodium in the flame caused a yellow line to appear the entire length of the slit. Lithium added to the flame caused a red line to show the entire length of the slit. The erbium spectrum did not extend above the solid; there was nothing like its spectrum coming from the gas immediately above the solid. This indicated that the emission was from the solid and not from the vapour near the solid.

2. *Identity of Emission from the Oxide and from a Phosphate Bead.*—There has been some difference of opinion as to whether the emission is the same from the oxide as from the phosphate. To determine this a small portion of powdered oxide was intensely heated in the oxy-hydrogen flame and finally fused down into a cream-coloured bead, without the use of any flux. I mounted this bead before the slit of the collimator and immediately above it another sample in which a syrupy phosphorus pentoxide had been used as flux. The two specimens were in the same flame and seen at the same time, one above the other. The two spectra were identical; so far as I was able to judge the red band appeared in the same place and in the same manner. The green lines appeared identical in the two spectra. In one trial it seemed as though the green bands stood out a little more distinctly in the case of the specimen prepared with the flux. This appearance was not characteristic and was not very marked in the one case that was noted.

3. *Relation between Emission and Absorption.*—It has been recognised, almost from the first, that there is a very close agreement in both the positions and intensities of the emission and absorption bands. J. A. Anderson (*Astrophysical Journ.*, 1907, xxvi., 93), in the summary of his investigations, concluded that the emission is due to the oxide itself, and that it corresponds exactly to its absorption at the same temperature. The absorption of the solid changes with temperature, the change consisting in a widening of the bands, and in some cases a shift toward the red, with an increase of temperature. Anderson further concluded that the absorption of the dry compounds is different for different compounds of the same element.

In the case of the oxide under consideration in the present paper the absorption bands at room temperature and the emission bands during incandescence were located visually with a spectrometer. To obtain the absorption spectrum the fused oxide was placed before the slit of the instrument and the light of a carbon arc was focused upon it. As will be seen from Table I. the absorption bands occur in six groups, each group corresponding approximately in position to one of the broader emission bands. The single band at 0·436 μ may perhaps be the only visible member of still another group which may coincide with a feeble emission band which escaped notice.

4. *Fluorescence and Emission.*—The oxide under investigation was excited to fluorescence by cathode rays in a vacuum tube. The spectrum, as had been noted by earlier students of the rare earths, was distinctly different from the spectrum obtained when the same specimen was heated to incandescence. A broad red band began at wave-length 0·6065 μ and merged into a bright yellow band at 0·5880 which extended to 0·5730. A green band began at 0·5605 and ended at 0·5450. A dark space followed, and then another green band between 0·5380 and 0·5020. There was brightness again beginning at about 0·4950, but this gradually became less intense and ended at about 0·4730. The determination of the relations between these spectra lies beyond the scope of the present paper.

TABLE I.—*Absorption Bands at* +20° *and Emission Bands at* 1000° *observed in a Specimen of Commercial Erbium Oxide.*

Group.	Absorption. μ.	Absorption. $1/\mu \times 10^3$.	Emission. μ.
I (unresolved)	0·4180	2392	0·4100
	to	to	to
	0·4223	2368	0·4250
—	0·4361	2293	—
2	0·4534	2206	0·4500
	0·4571	2188	to
	0·4611	2169	
	0·4655	2148	0·4685
3	0·4916	2035	0·4885
	0·4936	2188	to
	0·4971	2169	
	0·4978	2148	0·5015
4	0·5198	1924	0·5135
	0 5222	1915	to
	0·5260	1901	
	0·5306	1885	0·5360
5	0·5407	1849	0·5360
	0 5417	1846	
	0 5438	1839	to
	0·5461	1831	
	0·5474	1827	
	0 5562	1798	0·5555
6	0·6400	1562	0·6400
	0·6521	1534	
	0·6532	1531	to
	0·6551	1526	
	0·6656	1502	
	0·6751	1481	0·6750

5. *Development of Selective Emission with increasing Temperatures.*—In order to get a general idea as to the growth of the emission spectrum with increasing temperatures, I placed some of the erbium oxide powder between two thin plates of clear quartz. In the midst of the powder I placed one of the junctions of a thermo-couple made of Pt, Pt-Rh, wires. The couple was joined through the proper resistance with a Paul unipivot pyrometer, reading approximately in degrees centigrade. The appearance at different temperatures may be described as follows:—

600° C. A broad faint haze in the yellow-green, ending abruptly on the side toward the blue. No red discernible.

640° C. Red band clearly seen and more light in the green, but it ended abruptly as before.

680° C. Sufficient light so that the slit could be narrowed. The green bands began to stand out from the green haze, which served as a background.

770° C. A faint suggestion of another band in the blue.

800° C. The red continued to stand out well, although there was a faint continuous spectrum over the whole field.

930° C. Two faint bands seen beyond the green. In the red was a dark portion, as though there were two bands, separated from one another.

1000° C. No further question about there being varying degrees of intensity in the red. The continuous spectrum was more pronounced, yet all the bands showed well.

1120° C. The band appearing in the blue seemed to be of two parts, while in the violet there seemed to be a very dim band made up of three parts. At this temperature the continuous spectrum began to mask the bands.

1220° C. The red had spread into a much broader band. In the extreme violet another band could be dimly seen. The boundaries of the green bands could be seen distinctly. The other bands appeared as broad patches, slightly more intense than the continuous spectrum which had pretty completely masked them.

6. *Emission not Due to Excitation by Radiation of Short Wave-lengths.*—In the article by J. A. Anderson it was suggested that the simplest and best way to settle the question as to whether the radiation is due to the oxide itself or to a surface-layer of gas, formed by the action of the flame, would be to heat the oxide without using the flame. In order to make this test and at the same time prevent the excitation of fluorescence by any ultra-violet radiation from the flame itself, I made a nickel box about 2 cm. in diameter and 7·5 cm. in depth. This box was heated by a blast-lamp flame playing against the bottom and sides. The specimen to be examined was mounted at the end of a bent quartz rod, in such a manner that it could be quickly swung up out of the box and before the slit of the collimator. When heated in this manner the red and the green bands were seen just the same as when the specimen was heated by the flame directly. The nickel box was not white hot, and the bands persisted for several seconds after cooling had begun, due to removal from the box. Since performing the experiment with the nickel box I have heated specimens in the electric furnace to be described in a subsequent paragraph, and have found the spectrum to be the same as when heating directly with the flame. This is taken to establish that the banded emission spectrum is not due in any way to peculiar properties of the flame, but that it is a thermal effect and independent of the manner of heating.

VACUUM ARC SPECTRA OF VARIOUS ELEMENTS IN THE EXTREME ULTRA-VIOLET.*

By Prof. J. C. McLENNAN, F.R.S.; D. S. AINSLIE, M.A.; and D. S. FULLER, M.A., University of Toronto.

(Continued from p. 81).

4. *Thallium.*—The vacuum arc for thallium was obtained by placing the metal in cups in the end of iron electrodes. A continuous intense arc was obtained with a current of 6 amperes. The measurements for wave-lengths below λ 2000 A are given in Table V. Saunders has measured the vacuum arc and spark spectra for this metal, and the results in full, as given by him, are included in the Table. Comparing the results for the arc spectrum as measured in our work with those given by Saunders, it would seem that several additional lines occur in our measurements which are given in his results presumably as spark lines only. This may be due to a difference in the conditions under which the arc was operated. Generally speaking, Saunders' measurements are higher than ours. This may be due to the fact that he based his work on standard lines different from those used by ourselves. Takamine and Nitta measured two lines in the vacuum arc spectrum of this metal at λ 1971·8 A and λ 1908·2 A (in air). In our results a line was noted corresponding to the latter, but none for the line λ 1971·8 A. Below λ 1814·2 A several new lines were observed and measured.

5. *Tin.*—The vacuum arc spectrum of tin was obtained by using a sample of chemically pure metal in iron electrodes. With a current of 5 amperes on closed circuit an intense intermittent arc was secured. The measurements obtained for this metal below λ 2152 A are given in Table VI., together with results obtained by Saunders, who measured the arc spectrum of tin down to λ 1811·29 A. Between λ 2092·14 A and λ 1811·20 A four lines were

* From the *Proceedings of the Royal Society*, A, xcv., 316.

TABLE IV.—*Copper.*

Intensity.	The Authors. λ (A).	1/λ.	Eder and Valenta. λ (A).	Handke. λ (A).
6	2037·3	49,084	2037·24	
4	2026·2	49,353	2025·53	
4	2001·0*	49,975		
4	1979·6	50,515	1979·26	1749·9
				1747·1
4	1748·6	57,819		1741·0
4	1739·7	57,481		1739·0
6	1721·8	58,080		1721·9
4	1708·5	58,531		1708·5
2	1704·9	58,654		1705·0
4	1693·4*	59,053		
1	1692·5	59,084		1692·3
4	1686·7	59,301		1686·6
2	1684·6	59,361		1684·3
1	1681·7	59,428		{ 1681·9 1681·2
2	1679·1	59,556		1679·0
2	1674·6	59,680		1674·5
2	1671·5	59,826		1671·6
2	1670·1	59,877		1669·8
2	1651·9	60,536		1651·9
8	1642·1	60,898		1641·8
8	1594·2	62,727		1594·2

* Lines for which no corresponding values were found in previous work.

TABLE V.—*Thallium.*

	Arc spectrum			Spark spectrum.
Intensity.	The Authors. λ (A).	1/λ.	Saunders. λ (A)	Saunders. λ (A).
14	1907·8	52,416	1908·68	1908·68
6	1891·8	52,860	1892·72	1892·72
				1881·19
				1871·47
				1837·96
2	1827·3	54,725		1828·00
6	1814·2	55,121	1814·72	1814·72
8	1792·2	55,797		
6	1660·0	60,241		
6	1653·8	60,467		
14	1561·8	64,029		
16	1559·0	64,144		
5	1538·5	64,998		
4	1508·2	66,304		
6	1499·8	66,676		
2	1491·0	67,069		
4	1478·0	67,659		

TABLE VI.—*Tin Vacuum Arc Spectrum.*

Intensity.	The Authors 1/λ.	1/λ.	Saunders. λ (A).
12	2152·5	46,457	2152·08
			2149·43
			2114·74
			2092·14
2	2041·2	48,990	
1	1941·0	51,520	
20	1899·8	52,637	
6	1831·4	54,603	
20	1811·2	55,212	1811·29
16	1756·6	56,928	
1	1741·3	57,428	
10	1699·5	58,841	
6	1489·2	67,150	
15	1475·2	67,787	
4	1438·3	69,526	
4	1437·3	69,574	
4	1402·4	71,303	
4	1400·5	71,402	

measured by us which are not given in his work. It is noteworthy that among the lines missing from the spectrum as recorded by Saunders there is the line λ 1899·8 A, which, according to our work, is one of the strongest lines in the spectrum.

Below the range covered by Saunders' work several new arc lines were photographed and measured. The spectrum is remarkable for the number of strong lines between λ 1500 and λ 1400. The table does not include lists of wave-lengths of those observers who investigated the spark spectrum only.

(To be continued).

THE FOUNDER OF MODERN CHEMISTRY.

ON August 13, 1743, Antoine Lavoisier was born at Paris. His father, an opulent Farmer-General, spared no expense upon his education, and in the college of Mazarin where he studied he carried off several prizes for proficiency in classical acquirements. He soon, however, devoted himself to the sciences and entered with fervour upon the study of mathematics, botany, astronomy, and chemistry. The earliest of his contributions to science was an analysis of gypsum, presented to the Academy of Sciences in 1765. In 1768 he wrote a treatise on the Lapsis Specularis, relating to the composition of the great strata forming the basin of Paris, for which he was admitted into membership of the Academy.

From this time onward Lavoisier began to devote himself more and more exclusively to chemical enquiries. He had received the benefit of a thorough education in the various branches of natural philosophy, and was fully acquainted with all that was then known of chemistry. He possessed, moreover, an almost spiritual ardour in the pursuit of scientific truth, and was filled with the ambition to distinguish himself among its students. He was also in possession of ample wealth, so that the most costly apparatus and the most expensive experiments were at all times within his reach.

Thus equipped he continued for several years a series of lengthy and laborious experiments. His discoveries were in some cases anticipated by others, notably Black, Watt, Cavendish, and Priestley, but his independent studies added confirmation to their theories regarding the nature of gases and contributed to his doubts concerning the validity of Stahl's theory, then universally held, that the property of combustibility was due to the presence in the combustible substance of a fiery principle, Phlogiston. For practically a century the doctrine had been accepted as correct, that when a substance burns, the Phlogiston escapes, leaving behind the ash, or calx, as it is called in the case of metals. Lavoisier's experiments proved that the weight of the products of combustion was greater than the weight of the original substance, and the inference which he drew was, that calcination is caused by the union of air with the combustible substance and not by the loss of any body, such as Phlogiston, combined with it.

Lavoisier followed up the line opened by this discovery with further enquiries into the action of heat upon the diamond, in which he was assisted by a public-spirited jeweller. The calcination of tin, charcoal, and other substances was also investigated, and resulted in a number of important contributions to the progress of science. Some of his conclusions have undergone modification since his day, but his main theories remain unchallenged. After the discovery of the gas oxygen by Priestley and Scheele in 1774, Lavoisier was able to put forward a new interpretation of the process of combustion of substances in air; and with that interpretation modern chemistry was born.

In the midst of these labours Lavoisier was called upon by Turgot, then Minister under Louis XVI., to superintend the manufacture of gunpowder, and the result of

his labours was to increase the explosive force of the compound by nearly one-fourth. After the Revolution, the National Assembly in 1791 requested his assistance in improving the system of finance, and his treatise, "Richesse Territoriale de la France," which contained the fullest account yet given of the production and consumption of the country, was by far the most valuable report ever presented to the Legislature. The Revolutionary Government appointed him a Commissioner of the Treasury, and in this and other offices he rendered invaluable assistance to the new regime and earned the appellation of "a great man and a good Republican." This did not, however, suffice to save him from the maëlstrom of the Revolution. When the Academies, accused of fomenting a counter-revolution, were dispersed, Lavoisier addressed a vigorous protest to the Convention.

"There is not," he said, "an academician who, if he had applied his intelligence and means to other objects, would not have been able to secure a livelihood and position in Society. It is on the public faith that they have followed a career, honourable without doubt, but hardly lucrative. If you allow the men of Science to retire to the country, to take other positions in Society and to devote themselves to lucrative occupations, the organisation of the Sciences will be destroyed, and half a century will not suffice to regenerate the order. For the sake of the national honour, in the interests of Society, as you regard the good opinion of foreign nations, I beseech you to make some provision against the destruction of the arts which would be the necessary consequence of the annihilation of the Sciences."

Lavoisier had inherited the office of a Farmer-General prior to the Revolution, and, the arrest of all farmers-general who had held office under the monarchy having been ordered, he was arrested with twenty-seven others. The charge—ridiculous certainly against Lavoisier—was that of "having mixed water and certain harmful ingredients with the tobacco they sold." They were all sentenced to death. Lavoisier asked for a fortnight's delay in order to complete some experiments he had in hand. This request afforded Coffinhal, the presiding judge, his only opportunity of figuring in the literature of Science. "The Republic," he said, "requires neither savants nor chemists; the course of justice cannot be suspended." On the following day, May 8, 1794, Lavoisier ascended the scaffold. The founder of modern chemistry went to the scaffold with placid dignity and his body was placed in an unmarked grave.

(I have felt justified in repeating this story both on account of the great weight of authority behind it and because it is otherwise consistent with what we know of Coffinhal's character, but I have not been able to verify it and accounts differ. The version above is that of Lenôtre, "Le Tribunal de la Terreur," p. 150).

The revulsion of feeling aroused by the unceasing stream of victims to the guillotine was already making itself felt, and the universal respect in which the illustrious chemist was held undoubtedly contributed to bring the Reign of Terror to an end. Within a few weeks Coffinhal himself was a fugitive. He disappeared after the Revolution of 9th Thermidor (July 7, 1794), and, reduced to a wreck by hunger and privation, was himself arrested and condemned to death on the 18th. It was quickly realised that the execution of Lavoisier was a crime against the whole intellectual world, and less than two years later the nation took part in a solemn funeral ceremony, and orations in his honour were publicly pronounced by the chief representatives of the Government.

"Compared with the growth of Science," said the Professor Minot, "the shiftings of Governments are minor events. Until it is clearly realised that the gravest crime of the Revolution was not the execution of the King but the execution of Lavoisier, there is no right measure of values; for Lavoisier was one of the three or four greatest men that France has produced."

E. C. R.

EMPLOYMENT OF CHEMISTS IN CHEMICAL WORKS.

In the "Fifty-fifth Annual Report on Alkali Works by the Chief Inspector to the Local Government Board," Mr. Littlefield and Dr. T. Lewis Bailey call attention to the more extended employment of chemists in chemical works. To all of these attention has been directed in past reports. Dr. Bailey's remarks express so well the views of many others that it may be well to reproduce them here.

"The more extended employment of chemists in chemical works generally is a hopeful sign, though one regrets that repeated attempts at persuasion in this direction in past years received comparatively little notice; it seems to have needed the upheaval of war to bring about a realisation of the disadvantages under which so many works were carried on in days gone by, when manufacturers either would not employ chemists at all or would only have such men as had been trained in the works themselves for the special purposes of those particular works. One has heard so frequently the excuse that a University-trained chemist is useless in works—in such cases it seems to have been assumed that a man taken direct from the University should have been able to drop immmediately, and without trouble, into the intricacies of a works laboratory and of works processes generally. There have been, undoubtedly, faults on both sides—on that of the University and that of the manufacturer. It is not desirable that educational institutions should attempt to train chemists simply and solely on a technical basis; the student should surely be given first a good sound scientific training, with a sufficiency of laboratory work to make him a painstaking and accurate manipulator, irrespective of the time taken to arrive at his results; then, and then only, should he be taught to adapt himself to questions of time-saving and shortened or rapid methods, coupled with the degree of accuracy desired for the end in view. He will then appreciate truly the evolution of technical methods necessary for the rapid control of the results of manufacturing operations.

"But training on either the one or the other of these lines only is surely insufficient to produce the character required for a satisfactory and successful works chemist, who may be required to take his place in ever varying branches of the industry.

"Further, when the manufacturer gets the product of this training, he still must not expect to have a man who can at once take his place under technical conditions, of which he cannot possibly know all the details; the manufacturer must now take up and complete the training, and ascertain what is the adaptability of the man in question. Some quite naturally become leaders of men, and so can in a short time be led on from the laboratory to process and even works management, in which, be it remembered, thorough knowledge of scientific principles is a necessity for the development and extension of the processes of manufacture—there is no finality and there can be no standing still. Others, again, have little ability as men leaders, but they may be excellent investigators and as such particularly suitable in other departments of a works which aims at being progressive.

"Simple process testers there will always be, but these are quite apart from the guiding hands and have no effect on development.

"May the near future see this all-important question take its proper place as one for serious consideration in all works where there is any pretension to permanency.

"In the immediate past the idea of progressiveness has been left too much to others; the attempt to stay where we were and work ever on old and stereotyped lines has been well nigh disastrous."

At this time increased national production is more urgent than ever before as essential for national prosperity. Three of the chief supports on which such prosperity will rest are efficient labour, scientific control, and co-operative effort.

BOARD OF TRADE ANNOUNCEMENT.

Trade with Hungary.

In view of the raising of the blockade, the Board of Trade have issued a General Licence under the Trading with the Enemy Legislation authorising with certain reservations the resumption of trade with Hungary.

The licence does not remove the existing restrictions upon the payment of debts and the return of property due or deliverable to persons in Hungary, in respect of pre-war transactions. Moreover, any permission which may be necessary in respect of any transactions under Defence of the Realm Regulation 41 D must be obtained from the Treasury.

The licence does not permit the importation from Hungary of any goods included in the Prohibition of Import Proclamations and not covered by a General Licence issued under those Proclamations. Further, export licences must be obtained from the Export Licence Department, 1, Queen Anne's Gate Buildings, Westminster, S.W. 1, before goods included in Lists "A" and "B" of prohibited exports are shipped to those countries. But no licences are now required in respect of goods included in List "C."

ORDER OF THE MINISTRY OF MUNITIONS.

Potassium Compounds.

Whereas the Minister of Munitions, by the Potassium Compounds (Partial Suspension) Order, 1919, dated March 14, 1919, suspended the operation of the Potassium Compounds Order, 1917, dated October 17, 1917, in so far as related to Kelp;

And whereas the Minister of Munitions is desirous of suspending the further operation of the Potassium Compounds Order, 1917.

Now, therefore, the Minister of Munitions hereby orders as follows:—

(1) The operation of the Potassium Compounds Order, 1917, as modified by the Potassium Compounds (Partial Suspension) Order, 1919, is hereby suspended on and after August 1, 1919, until further notice.

(2) Such suspension shall not affect the previous operation of the said Order or the validity of any action taken thereunder or the liability to any penalty or punishment in respect of any contravention or failure to comply with the said Order prior to such suspension or any proceeding or remedy in respect of such penalty or punishment.

(3) This Order may be cited as the Potassium Compounds (Complete Suspension) Order, 1919.

CORRESPONDENCE.

NOTE ON ALUMINIUM AND A DOUBLE SALT.

To the Editor of the Chemical News.

Sir,—If Mr. E. Rattenbury Hodges, whose communication under the above heading appears in your issue of August 8, p. 64, will refer to "Aluminium and its Congeners," by Mr. H. F. V. Little, B.Sc. (Chas. Griffin and Co., 1917), which is Vol. IV. of my "Textbook of Inorganic Chemistry," he will find on pp. 57 and 88 several interesting references to the action of nitric acid upon aluminium. Thus:—

"In comparison with its action on other metals, the action of nitric acid on aluminium is extremely slow. With 5 to 20 per cent acid at 25—30° the main reaction is as follows:—

$$Al+4HNO_3=Al+(NO_3)_3+2H_2O+NO.$$

With a large excess of acid, nitrogen appears among the gaseous products. A little ammonium nitrate is produced.

"Nitric acid of density 1·15 dissolves aluminium faster than the 1·45 acid, and the rate of solution of the metal increases with the fineness of division, thick foil dissolving very slowly, but coarse turnings much more rapidly." (See pp. 57—58). Again:—

"Aluminium nitrate, $Al(NO_3)_3.9H_2O$, is prepared by dissolving aluminium in nitric acid of density 1·42, and crystallising the solution." (See p. 88).

Several score of double salts of aluminium are mentioned in Chapter III. of the above mentioned work.—I am, &c.,

J. Newton Friend.

August 9, 1919.

NOTES.

Lead Isotopes.—Researches on the transformations of radio-active substances have led to the conclusion that chemical elements exist which have the same atomic number but different hydrogen equivalents. Such chemical elements have been called isotopes. Prof. Richards' determinations of the atomic weight of lead isotopes has given 206·08, as compared with 207·20 for ordinary lead. Prof. T. Lyman has determined the X-ray absorption wave-lengths of lead isotopes (*Proc. Nat. Acd. Sci., U.S.A.*, June, 1919), and finds that the critical absorption wave-lengths are identical to within the limit of error in the experiments.

The Profiteering Bill.—Although the need for this important measure is fully recognised, there has been a vast amount of criticism as to its contents and scepticism as to its value. The remarks of Sir Auckland Geddes, when moving the second reading, are so much to the point that we are reproducing them. "I would say to the House that this Bill embodies what we believe to be the best possible suggestion with regard to this difficult problem of tackling the making of quite unreasonable profits. We have examined other avenues, and we have explored them thoroughly. We see great difficulties in administering fairly and fully the powers which this Bill confers, but we see far greater difficulties in approaching the problem or in seeking for a solution of the problem along any of the other lines which I have indicated, and great as are the difficulties, great as they will be in administering the provisions of this Bill, there will be far greater difficulties and dangers arising from leaving the present position untouched. I firmly believe that it would be wrong of the Government to allow this House to disperse for a period of weeks at this time and not to ask from the House a weapon which it could use to deal with these great and, I think I may say, these admitted evils, and this weapon which we are asking for now will, I feel sure, in spite of the obvious difficulties of administration, not effect everything that we would wish. That is impossible in such a huge sphere and so complicated a problem, but it will achieve much, and I feel myself that in getting the local committees to work, committees which will have delegated to them under the proposals of the Bill the powers the Board of Trade is asking for, we may rely without any fear upon the sound common sense of the citizens of this country. It has been well said that we are a nation of shopkeepers. We are certainly a nation of traders, and people are not going to be so foolish—there may be individual mistakes—as to impose conditions that will make trade impossible. I feel perfectly confident that their sound, shrewd common sense, of which there are such reserves in the country, will make the provisions of this Bill work more smoothly than those who look at it merely from the centre might imagine, and I say more. The mere fact that it is intended that the powers should

be widely delegated will really give much greater confidence in the administration of the Act, as I hope it soon may be, than if the whole of the administration were done from or at the centre."

FRANKLIN MEDAL, 1919.—At the Meeting of the Committee on Science and the Arts of the Franklin Institute, held March 5, 1919, the following resolution was adopted:—"Resolved—That the Franklin Medal be awarded to Sir James Dewar, of London, England, in recognition of his numerous and most important contributions to our knowledge of physical and chemical phenomena, and his great skill and inventive genius in attacking and solving chemical and physical problems of the first magnitude."

HELIUM FOR DIRIGIBLES.—It appears that the first suggestion of the use of helium instead of hydrogen for dirigibles was made by the late Sir William Ramsay, but it was thought at the time that the expense of production would be prohibitive. The discovery that some of the natural gums of Kansas and other localities contained as much as one per cent helium brought the suggestion within the bounds of practicability.

FROM a small pamphlet entitled "Bermondsey's 'Bit' in the Great War," by Henry Fuller Morris (Alderman of Bermondsey), we learn that the first supplies of H.M.T. used as antidote to German "Poison Gas" were made in Bermondsey. The manufacture had to be undertaken at a few hours notice with hastily-erected machinery, and the repulsive nature of the material rendered it very difficult to obtain the necessary labour. A story is told of "Bill" the foreman and "Dan" his mate, who at a time of great anxiety came to the manager and said, "We are going to see it through, Dan and me—even if it kills us"; and see it through they did, for within a month it was being produced at a third of the price quoted by Americans.

IT is abundantly clear that German manufacturers are completing plans for a revival of the methods of peaceful penetration in this country. Publicity is of first-rate importance in the development of business, and our erstwhile enemies are busy seeking out the best mediums in the trade and technical press in the hope of securing space to boom the coming German trade push. The ink of the Peace Treaty was scarcely dry before German manufacturers got into postal communication with the leading British journals, requesting copies and advertisement rates. Here is a typical example, which reached the offices of the *Engineering Review*. It is dated from Cologne, July 3, 1919, and reads:—

"Please send us a copy of your periodical that we may judge if it is advisable for us to advertise in your paper.—(Signed) HORBACH AND SCHMITZ."

We need hardly observe that the application has been ignored. We have no use for the Germans, nor for advertisements to assist them in dumping their wares to the detriment of British manufacturers. This journal is conducted in the interests of British industry and of commercial and technical intercourse between the British Dominions and friendly nations, and we repeat that its pages will not be available for assisting the recovery of markets for German and Austrian goods. We shall not soon forget the German atrocities in Belgium and France, nor the terrible treatment meted out to our soldiers who happened to fall into their hands. In our issue of November last we gave an art paper supplement, depicting a group of British prisoners starved by the Germans. The illustration bore the inscription—"When the Germans claim freedom in the markets of the Empire, remember this." The *Engineering Review*, at any rate, will be no party to assisting in the dumping of enemy-made goods in this country, and correspondence emanating from enemy firms will be relegated to the waste-paper basket.—*Engineering Review*, July, 1919.

H.M. TRADE COMMISSIONER AT WINNIPEG points out that he is experiencing delays in receiving both letters and second-class matter (catalogues and printed matter) on account of their being wrongly addressed. His address is 610, Electric Railway Chambers, Winnipeg, and United Kingdom firms desiring to send catalogues, &c., should therefore note this.

THERE have recently been an increasing number of cases where firms desirous of obtaining information have addressed their enquiry both to the Department of Overseas Trade, London, and to the Consular Officer or Trade Commissioner of the district or country in which they are interested. It should be understood that the Department of Overseas Trade refers any such enquiries which cannot be directly dealt with to the Commercial Secretaries, Consuls, &c., to whom it looks as its agents in the collection of commercial intelligence. In these circumstances, the method of addressing enquiries to both sources not only leads to needless duplication of work on the part of the Department, the Consul, and the firm itself, but frequently causes unnecessary loss of time. It is therefore recommended that all such applications for information should be addressed solely to the Department of Overseas Trade (Development and Intelligence), 4, Queen Anne's Gate Buildings, Old Queen Street, London, S.W. 1, who may in frequent cases already have the required information on file.

CZECHO-SLOVAK CORRRESPONDENCE.—The Czecho-Slovak Legation in London have expressed their willingness to secure the services of competent men for Czecho-Slovak correspondence and for the translation of catalogues and printed matter into the Czecho-Slovak language, in order to facilitate the development of commercial relations between British firms and those in the Czecho-Slovak Republic. Firms wishing to avail themselves of this offer should communicate with the Commercial Attaché, Czecho-Slovak Legation, 9, Grosvenor Place, S.W. 1.

CHEMISTS AND THE ZEEBRUGGE OPERATIONS.—Dr. T. S. Price, head of the chemical department of the Birmingham Technical School, Mr. S. A. Brazier, and Mr. A. S. Wood have during the war period carried out valuable research work on behalf of the Government. The Education Committee report that Dr. Price was appointed Lieut.-Commander in the R.N.V.R., and that he has since received the O.B.E. (Military Division), and that Mr. Brazier was also given a commission. They first carried out valuable work in connection with the manufacture of diethylamine and acetal, and later at the Royal Naval Experimental Station undertook official chemical investigations for the Government as a result of the German use of poison gases. Many present and former chemical students at the school were engaged in gas manufacture. Later the production of gases used for smoke screens and smoke boxes in the Navy engaged attention, and the smoke material manufactured at the station was that which was chiefly used in the Zeebrugge and Ostend operations. Many of the volunteers who actually worked the smoke appliances during the operations were students of the Birmingham University or Technical School.

IRON AND STEEL INSTITUTE.—*Autumn Meeting*, 1919.—The Autumn Meeting of the Institute will be held, by kind permission, in the House of the Institution of Civil Engineers, Great George Street, Westminster, on Thursday and Friday, September 18 and 19, 1919, commencing on Thursday at 10.30 a.m., and on Friday at 10 a.m. The following is the programme of proceedings:—

Thursday, September 18 (*at* 10.30 *a.m.*).

General Meeting of Members.

Scrutineers will be appointed for the examination of voting papers for the election of new Members and Associates of the Institute.

Award of the Bessemer Medal for 1919 to Prof. Cav. Federico Giolitti, Ph.D. of Turin.

A General Conference on Fuel Economy will be held under the auspices of Committee No. 1 on Fuel and Ores, at which the following reports and papers will be read:—

"Report on Fuel Economy in Steel Works," by Dr. W. A. Bone, Sir Robert Hadfield, Bart., and Mr. A. Hutchinson. "Report on Fuel Economy in Foundry Practice," by Mr. H. J. Yates. "Fuel Economy in German Iron and Steel Works," by Messrs. Cosmo Johns and L. Ennis.

Friday, September 19 (at 10 a.m.)

General Meeting of Members.

Papers Nos. 10, 13, and 4 will be read and discussed.

Papers Nos. 1, 11, 6, 9, and 8 will be read and discussed.

Papers for which time cannot be found will be taken as read and discussed by correspondence.

The following is a list of Papers that are expected to be submitted:—

1. J. H. Andrew, J. N. Greenwood, and G. W. Green: "Nickel Crome Forgings."
2. W. A. Bone, Sir R. A. Hadfield, Bart., and A. Hutchinson: "Report on Fuel Economy in Steel Works." (With a Supplementary Report by H. J. Yates on "Fuel Economy in Foundry Practice").
3. E. D. Campbell: "Decarburisation of Steel."
4. J. J. Cohade: "On the Woody Structure of the Fractures of Transverse Test Pieces from Special Steels."
5. Cosmo Johns and L. Ennis: "Fuel Economy in German Iron and Steel Works."
6. R. H. Greaves: "Temper Brittleness of Nickel-Chrome Steel."
7. K. Honda: "Nature of the A_1 Transformation and a Theory of Quenching."
8. K. Honda and H. Takagi: "On the Cause of Irreversibility in Nickel Steels."
9. N. Hudson: "Experiments with Nickel Steels."
10. C. A. Keller: "Synthetic Cast Iron."
11. F. Rogers: "Brittleness in Nickel-Chrome and other Steels."
12. T. Murakami: "On the Structure of Iron-Carbon-Chromium Alloys."
13. J. H. Whiteley and A. F. Hallimond: "The Fluxing Action of Iron Oxides on Acid Furnace Structures."

THE INSTITUTE OF METALS.—*Autumn Meeting*, 1919.—The Autumn Meeting of the Institute will be held in Sheffield on Wednesday and Thursday, September 24 and 25. The following is the programme of the proceedings:—

Tuesday, September 23.

Information Bureau open at Office of Local Reception Committee, the University, St. George's Square, Sheffield.

Wednesday September 24.

Inspection of the University of Sheffield.

General Meeting of Members in the Mappin Hall of the University, St. George's Square, when the Vice-Chancellor will welcome the Members.

A selection of Communications will be read and discussed.

The Master Cutler (Sir Albert Bingham) will entertain all the Members of the Institute and their ladies to Lunch in the Cutlers' Hall, Church Street.

Visit to the Master Cutler's Works (Messrs. Walker and Hall).

(*a*) Motor Excursion through Peak district, *via* Ashopton, Hathersage, Bakewell, Haddon Hall, Chatsworth House; *or* (*b*) Visits to Works (for those not taking *a*).

Reception by the Lord Mayor of Sheffield in the Town Hall.

Thursday, September 25.

Inspection of the University.

General Meeting of Members in the University.

A selection of Communications will be read and discussed; those not so treated will be discussed by correspondence.

The Meeting will be concluded.

The following is a list of the communications that are expected to be submitted:—

Prof. P. G. H. Boswell, O.B.E. (Liverpool), on "Moulding Sands for Non-ferrous Foundry Work."

Prof. C. H. Desch, D.Sc., Ph.D. (Glasgow), Second Beilby Report on "The Solidification of Metals from the Liquid State."

Miss H. E. Fry (Teddington) and Dr. W. Rosenhain, F.R.S., Vice-President (Teddington), on "Observations on a Typical Bearing Metal."

Dr. W. H. Hatfield and Capt. G. L. Thirkell, B.Sc. (Sheffield), on "Season Cracking of Brass."

R. E. Leader, B.A. (Sheffield), on "The Early History of Electro-silver Plating."

E. A. Smith and H. Turner (Sheffield), on "The Properties of Standard or Sterling Silver, with Notes on its Manufacture."

Dr. J. E. Stead, F.R.S. (Middlesbrough), on "The Ternary Alloys of Tin—Antimony—Arsenic."

Dr. F. C. Thompson, B.Sc. (Sheffield), Note on Graphite and Oxide Inclusions in Nickel Silver."

Dr. F. C. Thompson, B.Sc., and F. Orme, M.Met. (Sheffield), on "Some Notes on the Constitution and Metallurgy of Britannia Metal."

Further particulars can be obtained of G. SHAW SCOTT, Secretary, 36, Victoria Street, Westminster, S.W. 1.

Assistant Chemist (21) seeks Situation in any branch of Chemistry. Sound Technical training. Five years' Analytical experience in Feeding-stuffs, Fertilisers, T.N.T., Acids, Coal-tar Products, Sugar, Starch Products, &c.—Address, H. E. J., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Analytical Chemist seeks Appointment. B.Sc. (Lond,), First-class Hons. in Chemistry, A.I.C. (Branch *e*), 1917. Pharmaceutical Chemist where general Analytical knowledge, exclusive of Metallurgy, is required.—Address, P. C., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist, three years' experience in large Tar Products Works before taking *active service, now demobilised*, desires Employment in London or the Provinces.—Address, T. T., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist or Physicist required to take charge of the Experimental and Analytical Laboratory of a firm of Engineers and general Founders in London. Applicants should preferably have some knowledge of Ferrous and Non-ferrous Casting and of Vitreous Enamelling State age, training, and salary desired.—Address, G. T., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Demobilised Chemistry Student (21), Inter. B.Sc. stage, desires opening in Works or other Laboratory in any capacity. Keen and accurate.—Address, "Demobilised," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Laboratory Assistant (Girl 21), Inter. B.Sc. standard, desires Employment in any branch of Chemistry. In or near London. Very keen. References if necessary.—Address, A. M., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Metallurgist wanted for Engineering Works, as Assistant. Must be experienced in general Ferrous Metallurgy and Metallurgical Laboratory work (including Heat Treatment and Metallography of Steels, &c.).—Apply, stating full particulars of training, qualifications, age, experience, and salary required, to Hans Renold, Ltd, Burnage Works, Didsbury, Manchester.

FOR SALE.—Quantity of Avery's Class B 1-lb. and 2-lb. Brass-Agate BEAM SCALES, fitted with scoops, *some on Mahogany stand; all recently adjusted and stamped; equal to new; prices from £4. Also some Avery's Class C 2-lb. and 3-lb. Steel* bearing BEAM SCALES, fitted with scoop pans; all in perfect condition; prices from £2 5s.—Address, Brooke Bonds, 14, White Horse Street, Leeds.

FOR SALE.—FURNISHED LABORATORY in large industrial town. Offers good opportunity for Analyst wishing to practise. Business carried on in these premises for twenty years before war. No local opposition.—Address, F. L., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London. E.C. 4.

THE CHEMICAL NEWS

VOL. CXIX., No. 3098.

HOW THE NITROGEN PROBLEM HAS BEEN SOLVED.*

By HENRY JERMAIN MAUDE CREIGHTON, Department of Chemistry, Swarthmore College, Member of the Institute.

(Continued from p. 89.

The Conversion of Nitric Oxide to Nitric Acid, &c.

THE following outline of the method of the conversion of the nitric oxide formed in the arc furnace into nitric acid, nitrates, and nitrites is illustrated by the diagram shown in Fig. 8.

Air is forced by a powerful blower into a large iron pipe-line which conveys it to the furnace, where it is partially oxidised to nitric oxide. The nitrous gases, which leaves the furnace at a temperature of somewhat over 1000° C., are then carried by a refractory-lined iron main to a tubular steam boiler, in which the gases during their passage through the heating flues have their temperature reduced to 200° C.—250° C. The steam produced in this boiler is utilised for operating evaporating kettles, running the engines which compress the air to work the pumps, &c. By the use of a turbo-generator in conjunction with the steam boiler, 10—15 per cent of the energy consumed in the furnace can be regenerated. The boiler may either form a part of the furnace, as in the Kilburn Scott process, or it may be separate, as in the Norwegian installations. It is important that the feed water of the boiler should be sufficiently hot to prevent moisture being deposited on the tubes, and this is readily accomplished by employing water from the cooling tank and also that which is used to cool the electrodes, thus giving a further saving of heat.

From the steam boiler the nitrous gases pass on to a cooling tank, where their temperature is further reduced to about 50° C. This tank consists of a large number of aluminium tubes over which cold water flows and through which the gases pass.

On leaving the cooler the gases are led to an oxidation tank. This is a large iron cylinder lined with acid-proof stone. Here the gases are allowed to remain in gentle motion for a short time, in order that the nitric oxide may be oxidised to nitrogen peroxide, the air which accompanies the gases from the furnace containing sufficient oxygen for this purpose. The extent of oxidation depends upon the length of time the gases are allowed to remain in the tank, twelve seconds being required for 50 per cent and 100 seconds for 90 per cent oxidation of a furnace gas containing 2 per cent of nitric oxide.

Blowers force the gases from the oxidation chamber through an aluminium pipe-line to the absorption towers. There towers are made of granite or iron and are filled with broken quartz, which is acted upon by neither the nitrous gases nor the nitric acid. At the Birkeland-Eyde plants, in Norway, these towers are 65·62 feet high and 18 feet in diameter. In these plants a series of three granite towers for the formation of acid followed by one of two iron towers for the formation of nitrite is usually employed. Centrifugal aluminium fans assist the passage of the gases through the towers.

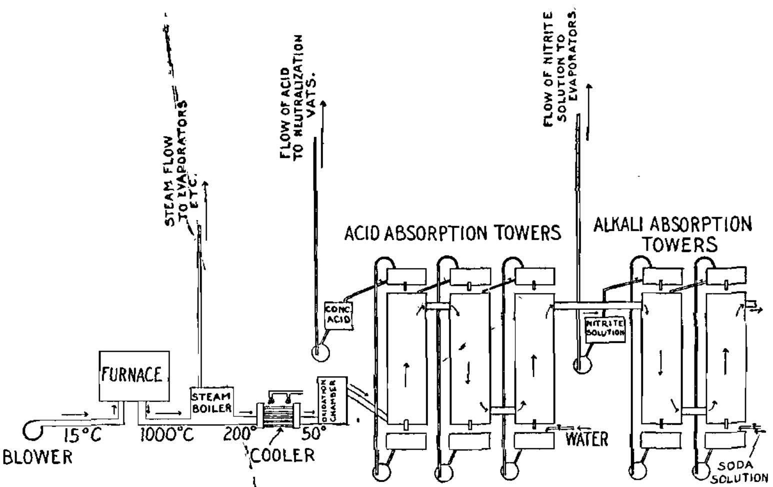


DIAGRAM OF APPARATUS FOR CONVERSION OF NITRIC OXIDE TO NITRIC ACID ETC.

FIG. 8.

The gases enter the first tower at the bottom, pass upwards, and thence are led by an earthen-ware pipe to the top of the second tower, down through which they pass and then through a second earthen-ware pipe are conducted to the bottom of the third tower. From the top of this tower they are conveyed to the first of the two iron towers. Water trickling down through the quartz in the third tower is gradually converted into dilute nitric acid which is received in a cistern at the bottom. The arrangement of the absorbing system is such that the liquid can be pumped up and passed repeatedly through the same tower, or used to percolate the preceding tower and so be brought in contact with a higher nitrogen peroxide concentration. After the absorbing liquid is pumped to the reservoirs at the top of the towers, it is automatically distributed in jets by earthen-ware pipes. When the acid concentration of the percolating liquid has attained a concentration of about 33 per cent, it is pumped to naturalisation vats and converted into calcium nitrate

* From the *Journal o the Franklin Institute*, April, May, and June, 1919.

or ammonium nitrate, or the dilute acid is further concentrated in the usual way.

Since on leaving the third tower the gases still contain upwards of 20 per cent of the original nitric oxide concentration, they are passed through the two iron towers percolated by a solution of caustic soda, in which absorption is more rapid and complete than in water. Of the entire quantity of nitrous gases passed through the five towers, about 97 per cent is absorbed. By regulating the time the nitrous gases are allowed to remain in the oxidation tank, the proportions of nitric oxide and nitrogen peroxide in the gas which comes from the third tower can be made such that practically pure nitrite will be formed in the alkali towers. Sodium nitrite, from nitrate, can also be produced by leading the nitrous gases directly to the second set of towers when their temperature has been reduced to 250° C., since at this temperature the two oxides of nitrogen are present in the gas mixture in equimolar proportions.

At Rjukan II, in Norway, the distance between the furnaces and the absorption towers is about 3000 feet.

Power, Current Supplies, Yields, &c.

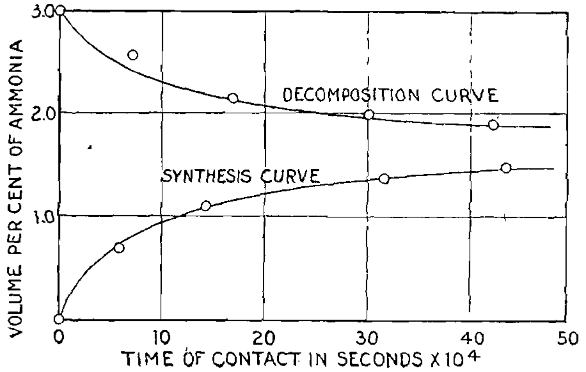
Of the different electrical processes for the fixation of atmospheric nitrogen, only the arc process is capable of intermittent operation with off-peak power. Arc furnaces, amounts to 675 kilogrms. and 525 kilogrms., respectively, per kilowatt year.

The production of nitric acid and nitrates from atmospheric nitrogen by the arc processes has made rapid strides in Norway, increasing from about 1000 tons in 1905 to an annual output of upwards of 100,000 tons at the present time. The Norwegian installations are located at Notodden and other parts of the Telemark district in southern Norway, where abundant water power is available at a very low cost. By constructing a dam a short distance below Lake Mös a reservoir was created with a storage capacity of 190 thousand million gallons, thereby ensuring a constant water supply for two of the largest power stations.

Advantages and Disadvantages of the Arc Processes.

The advantages of the arc processes may be summarised as follows:—

1. Cheapest cost of nitric acid (not of fixed nitrogen) if power can be obtained for 13 dols. per kilowatt year or less, and efficiently utilised in a large plant run continuously to capacity.
2. Efficient intermittent operation is possible with off-peak power.
3. The steam required for the concentration of the nitric



Fi . 9.

efore, may be installed wherever cheap three-phase er is available for sixteen to twenty hours per day. It is not even necessary to instal special generating machinery, as the ordinary standard voltages of 5500 and 6600 and periodicities of 25 and 60 are suitable.

A factory of convenient size for the fixation of atmospheric nitrogen is one which has a capacity of about 10,000 kilowatts, but in larger factories the cost per kilowatt, the operation cost, and the overhead charges per unit of finished product, are relatively lower.

The current supplies required for the first three furnaces that have been described are as follows:—

The Birkeland-Eyde Furnace.—Direct current for the magnetic field of 4500 lines of force per square centimetre.

Alternating current of 5000 volts and 50 periods for furnaces have a capacity of 600—4000 kilowatts.

The Schönherr Furnace.—Alternating current of 4200 volts and 50 periods for furnaces having a capacity of 600—1000 kilowatts.

The Pauling Furnace.—Single-phase alternating current of 4000—6000 volts and 50 periods for furnaces having a capacity of 400—1000 kilowatts.

The average yield of nitric acid in the Birkeland-Eyde furnace is between 500 and 600 kilogrms. per kilowatt year, although with some furnaces it has run as high as 950 kilogrms. In the Schönherr and the Pauling furnaces it acid and other purposes may be produced from the large amount of waste heat.

4. Direct production of nitric acid without intermediate products.
5. Free raw materials.
6. Labour requirements are small.

The following are the chief disadvantages of the arc processes:—

1. Large power requirements per ton of nitric acid.
2. Greater dilution of nitric acid when first produced than by other processes.
3. High installation charges for both power and plant.
4. Difficulties involved in the transportation of nitric acid.

II. The Direct Combination of Hydrogen with Nitrogen.

Outline of the Underlying Principles.

It has long been known that under certain conditions small traces of ammonia can be formed in a mixture of hydrogen and nitrogen, but it is due to the brilliant pioneer work of Haber and the subsequent development of his methods by the Badische Anilin and Soda Fabrik, that the production of ammonia from its constituents on a success-

fully commercial scale has been achieved. However, notwithstanding the fact that over a million tons per annum of synthetic ammonium sulphate are produced by the company just referred to, but very meagre details regarding the process are available.

The reaction between hydrogen and nitrogen leads to an equilibrium according to the equation—

$$8. \quad N_2 + 3H_2 \rightleftarrows 2NH_3.$$

This equilibrium is represented by the expression—

$$9. \quad K = \frac{p_{NH_3}}{p^{\frac{1}{2}}_{N_2} \cdot p^{\frac{3}{2}}_{H_2}},$$

where p represents the partial pressures of the respective gases at equilibrium and K is the equilibrium constant. If in (9) there is substituted for the partial pressure the product of the total pressure, P, and the fraction, C, which each gas forms of the total volume at equilibrium, the equation takes the form—

$$10. \quad P \cdot K = \frac{C_{NH_3}}{C^{\frac{1}{2}}_{N_2} \cdot C^{\frac{3}{2}}_{H_2}}.$$

The formation of ammonia from hydrogen and nitrogen is an exothermic reaction, and at ordinary temperatures it

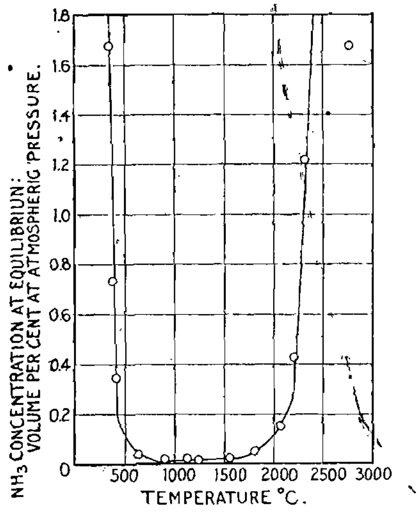
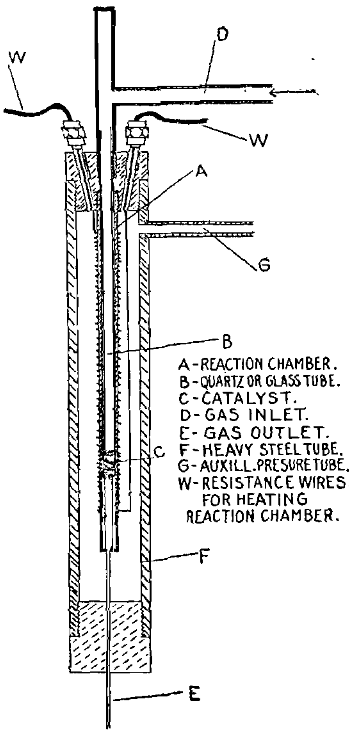


FIG. 10.

is accompanied by an evolution of 11,890 grm.-calories per mole of ammonia. It follows, consequently, in accordance with Le Chatelier's law, that the concentration of ammonia present in the gas mixture at equilibrium must diminish as the temperature at which the reaction takes place is increased. In order, therefore, to obtain a high concentration of ammonia, the temperature must be kept as low as possible. Unfortunately, on the other hand, a high temperature is necessary to obtain a favourable velocity of reaction.

The thermal synthesis of ammonia has been studied recently by Maxted (*Journ. Soc. Chem. Ind.*, 1918, xxxvii., 232) by passing mixtures of hydrogen and nitrogen through a small arc contained in a capillary tube. His investigations showed, as is illustrated graphically in Fig. 9, that at a temperature of about 3000° C., the amount of ammonia present in the gas mixture after passing through the arc increased with the time the hydrogen-nitrogen mixture remained in contact with the arc. Since the "synthesis curve" indicated that, under the conditions employed, the ammonia concentration at equilibrium is between 1·5 and 2 per cent by volume, hydrogen-nitrogen mixtures containing 3 per cent of ammonia were passed through the arc. As is shown by the "decomposition curve" in Fig. 9, the ammonia concentration being above its equilibrium value sank instead of rising after contact with the arc. This second curve shows that the equilibrium concentration of ammonia is about 1·7 per cent at atmospheric pressure under the conditions studied. Maxted has also plotted out approximately the complete experimental ammonia curve up to a temperature of 3000° C. This curve is shown in Fig. 10.

As it is evident from equation (10) that, for a given temperature, the ammonia concentration at equilibrium will be higher the greater the pressure at which the reaction is carried out, the best conditions for the formation of ammonia from its constituents are, therefore, a high pressure and a low temperature. But as the velocity with which equilibrium is attained under the latter condition is extremely slow, it is accelerated by employing a catalyst. By means of suitable catalysts it is possible to attain equilibrium rapidly and to produce satisfactory concen-



VERTICAL SECTION OF A HABER FURNACE

FIG. 11.

trations of ammonia at pressures between 150 and 200 atmospheres at 500° C. to 600° C. But even with the most active catalysts at present known it is difficult to obtain satisfactory results below the former temperature. On the other hand, it is unnecessary to operate at temperatures over 700° C., for with a gas mixture containing one volume of nitrogen to three volumes of hydrogen the maximum concentration of ammonia is rapidly attained below this temperature. With this gas mixture the equilibrium concentration of ammonia decreases with rise in temperature at a constant pressure, and for a given temperature increases with the pressure, as is illustrated by the data given in Table IV.

TABLE IV.

Temperature ° C.	Equilibrium concentration of ammonia at pressures of— 1 atmosphere.	100 atmospheres.	200 atmospheres.
400	0·48	—	—
500	0·13	10·7	18·1
550	—	7·0	12·2
600	0·048	4·5	8·3
650	—	3·0	5·8
700	0·021	2·1	4·1
750	0·0159	1·54	2·99
800	0·011	1·1	—
850	0·0089	0·874	1·68
950	0·0055	0·542	1·07
1000	0·0032	—	—

The Technical Synthesis of Ammonia.

The essential principles of the Haber furnace are shown diagrammatically in Fig. 11. The reaction chamber consists of a thin wrought iron or steel tube, A, inside of which is contained a second tube, B, of quartz or glass which is narrowed towards the lower end where the catalyst is contained between asbestos plugs. The tube A is wound on the outside with a heating resistance wire, W. The gas mixture enters the reaction chamber through D and leaves the furnace at the bottom through E. The reaction chamber is enclosed in a much stronger steel tube, F, in which a high pressure is maintained, so as to prevent the hot, thin, steel tube from bursting under its high internal pressure.

Many difficulties have been encountered in the construction of the Haber furnace so as to maintain pressures of over 150 atmospheres at temperatures of 500° C. to 600° C. At about 400° C. iron loses its solidity to a very extraordinary degree. Steel loses its carbon at the temperatures employed, thus reducing to a minimum its capacity of withstanding pressure. Iron becomes pervious to hydrogen under the high pressures, and its properties change. Further, the wall of the reaction chamber rapidly deteriorates under the influence of the ammonia mixture at high temperatures. While these difficulties have been overcome the details have been kept secret. Also there is but little information regarding the details of the construction of the furnace and its operation. It is known that the process is not without danger, as very *small amounts of oxygen or air are sufficient to cause explosions* at high pressures, but this danger is guarded against by having the apparatus in bomb-proof chambers.

Since the electrical method of heating is attended with many difficulties, a system has been adopted in Germany in which a sufficient quantity of air is introduced into the catalyst chamber, in such a manner that the proper reaction temperature is maintained by internal combustion. While this method of heating simplifies the construction of the furnace, it is liable to give rise to explosions owing to the incomplete combustion of the air.

The hydrogen-nitrogen mixture is forced through the furnace at such a velocity that an ammonia concentration of about 8 per cent is maintained. On leaving the furnace the gases pass through a refrigerating system where the ammonia is liquefied, while the hydrogen and nitrogen are returned to the reaction chamber and are again passed over the catalyst. Since in the reaction the first portions of ammonia are formed more rapidly than successive increments it is desirable to remove the ammonia as completely as possible before returning the residual gases to the reaction chamber. The maximum temperature that can be employed in the refrigerating system depends upon both the ammonia concentration and the pressure of the gas mixture. In Table V. is recorded the theoretical percentage of ammonia left in a gas under two different pressures after passing through a refrigerating system at the designated temperatures.

Of the various catalysts investigated for accelerating the velocity of the synthetic formation of ammonia, by far the most effective is osmium, but, unfortunately, the world's supply of this metal does not amount to much over 200 pounds, and the annual production is very small. Next in order comes uranium, which, in the form of the carbide, crumbles under high pressures to a fine powder possessing at 500° C. a very high catalytic activity. In using this catalyst it is essential that no water be present in the gases. Besides these two metals, iron, tungsten, molybdenum, molybdic acid, ammonium molybdate, and manganese are good catalysts for this reaction. The catalytic activity of tungsten depends in a large measure upon the manner in which it is prepared. It is worthy of note that platinum, although very closely related to osmium, possesses but a very slight catalytic activity.

TABLE V.

Temperature ° C.	Per cent of ammonia remaining in the residual gas mixed when the pressure is— 150 atmospheres.	200 atmosphere.
0	2·7	2·1
—10	1·9	1·4
—20	1·2	0·9
—30	0·76	0·57
—40	0·47	0·35
—50	0·25	0·19
—60	0·13	0·1

Certain foreign substances—"promoters" have been found to increase the activity of the catalyst. The most effective of these are the oxides and hydroxides of the alkali metals and of the metals of the alkali earths. For example, an iron-potash catalyst is particularly active. In many cases just a minute quantity of the promoter is sufficient to increase the catalytic activity.

As is so often the case with catalysts, those employed in the synthesis of ammonia are very susceptible to poisoning. Thus sulphur, selenium, tellurium, phosphorus, arsenic, boron or their hydrides, as well as lead, bismuth, tin, and many organic compounds behave as poisons. Extremely minute quantities of oxygen-sulphur compounds, which are almost always present in the so-called pure gases of commerce, suffice to render the catalyst either absolutely inactive or to diminish its activity very considerably. Iron prepared from its oxide containing 0·01 per cent sodium sulphate or 0·1 per cent sulphur is quite useless as a catalyst. Recognition of these facts necessitates the preparation of the catalyst free from such poisons, as well as very careful preparation of the gases employed in the reaction. Since as little as one part of sulphur in a million in the gas mixture can be injurious, even electrolytic hydrogen must be further purified.

TABLE VI.

Time of contact with catalyst in seconds.	Percentage of ammonia formed.	Yield of ammonia in kilogrms. per hour per litre of catalyst space.
0·34	0·65	2·7
0·56	0·94	2·3
1·8	1·8	1·4
3·6	3·2	1·25
7·2	4·7	0·91
10·8	5·1	0·65
24·5	6·8	0·38

The time of contact between the gas mixture and the catalyst influences the amount of ammonia formed. This is illustrated by Table VI., which gives both the percentage and yield of ammonia produced at 550° C. and a pressure of 150 atmospheres in the presence of an iron-potash catalyst.

The data in Table VI. shows that for a catalyst chamber of given size the highest yield of ammonia is obtained when the time of contact and the percentage of ammonia formed are both small. However, since any

decrease in the percentage of ammonia formed involves an increase in the number of circulations of the gas mixture through the reaction chamber and the delivery of a greater quantity of heat to the refrigerating system, the most economical condition for the synthesis in not a maximum yield of ammonia per hour, but an optimum rate of circulation of the gases.

The variation in the percentage and yield of ammonia with temperature and pressure, employing an iron-potash catalyst and time of contact of 1·8 seconds, is illustrated in Table VII.

It has been found that the best results are obtained when the pressure in the reaction chamber is maintained at 180 atmospheres. Regarding the most suitable working temperature, Maxted (*loc. cit.*) points out "it must he borne in mind that, as the synthesis is usually carried out, the percentage of ammonia formed per passage never approaches the equilibrium value for the tempetature and pressure used, and thus, within limits, of course, reaction velocity with play an even even more important *rôle* in the determination of the amount of ammonia formed during the time of contact than the absolute value of the equilibrium ammonia percentage. If, on the other hand, the temperature employed be so high that the desired percentage of ammonia unduly approaches the equilibrium percentage, the increase in the reaction velocity due to increased temperature will no longer compensate for the decreased equilibrium ammonia content."

TABLE VII.

	Per cent NH_3.	Yield in kgrms. per hour per litre of catalyst space.
Pressure = 150 Atmospheres.—		
Temperature = 530° C. ..	1·85	1·55
Temperature = 580° C. ..	3·57	2·73
Temperature = 550° C.—		
Pressure 50 atmospheres ..	0·55	0·42
" 150 " ..	1·8	1·4
" 180 " ..	3·5	2·7

On account of the small and complicated units employed in the Haber process, a large amount of highly skilled labour is required. Further, the technical control of the process is of so great importance and requires such skill that many months are necessary to train a technical staff of experts.

A process which resembles the Haber process has recently been invented in this country by De Jahn, of the General Chemical Company, but very little is known regarding its details. One great advantage of this process over that developed by Haber is that the reaction is carried out at a much lower pressure. Ammonia is formed by passing a mixture of hydrogen and nitrogen at 520° C. to 540° C., under a pressure of 80 to 90 atmospheres, over a catalyst formed by igniting a salt of cobalt, manganese, titanium, cerium, boron, uranium, or silicon upon a carrier of pumice, and then heating the product (after reduction in hydrogen) with metallic sodium and anhydrous ammonia at 300° C. Satisfactory results have also been obtained with a catalyst made by reducing nickel oxide on pumice with hydrogen at 550° C., adding a small amount of metallic sodium, and heating in anhydrous ammonia to 450° C. With this catalyst 4·5 per cent by volume of ammonia is obtained under a pressure of 80 to 90 atmospheres at a temperature of 520° C. to 540° C.

Preparation of Hydrogen and Nitrogen.

The preparation and purification o[...] nitrogen involve one of the chief it[...] synthesis of ammonia.

The principal method employed fo[...] pure nitrogen is the low temperature s[...] It may also be obtained as a by-product [...] of formic acid from producer gas and s[...]

Although a pure hydrogen may be p[...] cally, its cost is very high. It may be produced much more cheaply by the alternate action of steam and water gas on iron. However, hydrogen prepared by this method contains 1 to 2 per cent of carbon monoxide, its presence resulting as follows:—During the reducing stage of the process, carbon monoxide decomposes according to the equation—

$$11.\ 2CO \rightleftharpoons CO_2 + C,$$

the carbon being deposited on the iron and reacting with the steam subsequently introduced, with the re-formation of carbon monoxide which contaminates the hydrogen. By a modification of the intermittent method, whereby instead of water-gas, a gas containing a sufficient concentration of carbon dioxide to prevent the separation of carbon, according to equation (11), is employed for reduction, hydrogen completely free from carbon monoxide and having as high a purity as the electrolytic gas, can be produced with practically no increase in cost. In addition to the methods mentioned, hydrogen may also be obtained as a by-product in the electrolytic manufacture of alkali and in the manufacture of oxalates from formates.

Since the presence of even small traces of impurities in the hydrogen and nitrogen may poison the catalyst, their removal is essential. The methods employed depend on the nature of the impurities, and consist, according to the case, in filtering, washing, conducting over solid absorption agents, and so on. One good method is to bring the gases at high temperature into contact with the material of which the catalyst is prepared, before passing them over the catalyst. This material takes up the impurities, and from time to time is renewed.

Production and Costs.

The Haber process for the production of synthetic ammonia was installed in Germany in 1913 with a plant capacity of 30,000 tons of ammonium sulphate per annum. This grew to 60,000 tons in 1914; 150,000 tons in 1915; 300,000 tons in 1916; and 500,000 tons in 1917. At the present time ammonia is produced synthetically also in this country and in England. In 1918 the world's production of synthetic ammonia amounted to 140,000 tons.

Ammonia can be produced more cheaply by the synthetic method than by any other. In the Haber process the total energy consumption is given as 1·5 kilowatt hours per kilogrm. of nitrogen fixed. Trustworthy information indicates that anhydrous ammonia can be produced in the liquid condition by the Haber process for slightly less than four cents per pound.

Advantages and Disadvantages.

The chief advantages of the Haber process for the production of synthetic ammonia are—

1. Cheap ammonia.
2. Anhydrous ammonia in the liquid condition ready for immediate oxidation to nitric acid without purification.
3. Cheap and available raw materials.
4. Possibility of erecting comparatively small plants whenever required.

The following constitute the principal disadvantages—

1. Difficulties involved in the construction of apparatus to withstand high temperatures and high pressures.
2. The highly skilled technical staff required.
3. High repair and renewal costs.

(To be continued).

[...]er of the *Journal of the British Science* [...]ained—price 6d. per copy, postage 1½d. [...]o the Secretary, British Science Guild, [...] 1. The journal contains the report of [...]uild for 1918-19, various memoranda, [...]13th Annual Meeting, with addresses [...]he Right Hon. J. E. B. Seely, D.S.O., [...]J. Thomson, O.M., P.R.S., and the [...] Sydenham, G.C.S.I., F.R.S., on "Science and Labour Unrest."

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"BLUE JOHN" AND OTHER FORMS OF FLUORITE.

By BERTRAM BLOUNT and JAMES HARRY SEQUEIRA.

A good deal of work has been done on the properties of fluorspar or fluorite in the various forms in which it occurs in nature. Fluorspar as an industrial substance is ably dealt with in a memoir of the Geological Survey, entitled "Special Reports on the Mineral Resources of Great Britain," by Messrs. Carruthers, Pocock, and May, to which Messrs. Dewey and Brownhead have contributed. In this pamphlet no reference is made to the cause of the colour.

Derbyshire is properly regarded as the home of "Blue John." The famous Blue John Mine is in the Castleton district, and is thus described:—"The Blue John mine consists of a number of natural caverns in carboniferous limestone connected by tortuous pipes or fissures, and extending for a great distance. The blue fluorspar or 'Blue John' occurs as a lining on the walls of fissures and pipes, or in concentrically arranged layers. It is associated with barytes, and a leader of this mineral is usually considered a good guide to a deposit of 'Blue John.' The so-called veins are irregular flattened pipes running for a while almost horizontally, and then bending sharply up and down and cutting across the bedding. Where a vein is nearly flat its upper and lower surfaces are lined by coatings of blue fluorspar. . . ." This is enough for the present purpose, and it may be accepted that this is the best account extant of the occurrence of "Blue John" in Great Britain.

There is not much that we have been able to discover in foreign literature except a paper by H. W. Morse (*Proc. Am. Acad. Arts and Sci.*, 1906), which deals chiefly with the fluorescence of fluorite as studied in the spectroscope, but incidentally touches on some points of interest here. The essential statements are that the cause of the colour may be due to organic matter, and the conclusion arrived at is that "the question as to the cause of the colour of fluorspar still remains in this unsettled state." It is further said that the cause of the odour on heating is doubtful, and, further, that the gases expelled by this means are chiefly carbon dioxide, carbon monoxide, and hydrogen. Tests were made for helium on 10 kilos. of fluorite with a negative result, and the author of the paper feels so doubtful of his conclusion that towards the end of his paper he says:—"I saw no reason to question the statement that the colour of fluorite is due to organic matter." The evidence for and against this view is given in the ensuing notes of experiments made by ourselves.

Chemical Composition of Blue John.

Below are analysis of "Blue John" and of the white parts of the same mineral.

	"Blue John."	White portions of same sample.
	Per cent.	Per cent.
Calcium fluoride..	99·69	99·71
Alumina and ferric oxide ..	0·048	0·026
Manganese	nil	nil
Magnesia	0·006	0·005
Chlorine	nil	nil
Sulphur trioxide	nil	nil
Sulphur	trace	trace
Phosphorus	0·09	0·08

It will be seen that the difference between them is so small as to be almost inappreciable. It will also be noticed that metals such as manganese, which have been regarded as likely to be the cause of the colour, are practically absent.

The natural conclusion is that the colour of "Blue John" is due to some organic dye of animal origin, and that this has been absorbed by certain parts of the "Blue John" as distinct from others. Some support is given to this idea by the fact that there is usually a mechanical line of demarcation between the white and blue portions of typical pieces of "Blue John." This assumption of the cause of colour was tested by systematic extraction of "Blue John," powdered so as to pass a 60×60 mesh sieve, with chloroform, toluene, and aniline. Chloroform extracted 0·11 per cent of oily matter, toluene 0·04 per cent of a similar substance, and aniline nothing further. Acetone, nitrobenzene, and naphthalene were also tried, with negative results; the extracted mineral remained as deep a blue as before extraction. A combustion of the extracted material gave C = 0·046 per cent, showing that the amount of organic matter must be minute. The hydrogen was 0·17 per cent, but this is probably due to a small quantity of water combined or occluded, and the same remark may apply to the carbon, which may have existed as liquid carbon dioxide in the crystals. The "Blue John" after combustion was colourless.

It may be remarked that all these experiments were made on the mineral direct from the mine. Earlier experiments were made on "Blue John" prepared as ornaments, and at that time the authors were not aware that the handsomest specimens are filled with resinous matter in order to make them easier to handle and to turn. Probably on this account other chemists have been misled into the belief that the colouring material is organic, because they have found organic matter in the samples which they examined, and supposed that it was of natural origin. It remains a fact, however, that organic matter exists in "Blue John." This organic matter is not affected by a temperature of 150°. When a temperature of about 350° is reached the "Blue John" decrepitates and the colour disappears.

Gases from "Blue John."

On account of experiments, which will be described later, it was supposed that the colour of "Blue John" might be due to the action of radium, and many trials were made in this direction. As is well known, glass is easily coloured by the rays from radium, and a series of experiments was made by one of us.

While these experiments were proceeding another method was adopted for the same end. A fairly large quantity (about 50 grms.) of "Blue John" direct from the mine, not impregnated by any extraneous resinous material, was heated in a hard glass tube, and the gases were pumped out. After the carbon dioxide, hydrogen, and nitrogen had been removed, the remaining inert gases were examined spectroscopically in a Plücker tube. Argon was present, but helium was not. The deduction is that the gases consisted only of those that occur naturally in rocks and minerals which readily decrepitate.

Green Fluorspar "Green John."

This is similar to "Blue John," but decrepitates with greater violence. Both varieties fluoresce on heating, the light from the green kind being more vivid. Green fluorspar, called conveniently "Green John," and so referred to hereafter, appears to be much rarer than "Blue John," and it was only by the kindness of a friend that a specimen of good quality was obtained. Others taken from Mines in Durham and Cornwall were evidently less pure. As the quantity of good "Green John" available was somewhat small, our examination of it was necessarily limited, and the gases which are given off on decrepitation were not analysed, the quantity at our disposal being too small for any satisfactory examination.

Systematic experiments by one of us (J. H. S.) were carried out at the London Hospital on the action of radium and X-rays on various samples of fluorspar. The notes made at the time are here recorded.

(A) "*Blue John*": *Experiments with Radium.*

1. Two pieces of banded fluorspar ("Blue John") were exposed to radium, contact being made with a plate 2·5

cm. square containing 30 mgrms. of radium salt under a varnish.

As a result of this exposure both pieces of spar changed colour, the white parts becoming bright blue and the blue becoming darker. In ten days these changes were well marked.

2. Pieces of "Blue John," "Green John," and white fluorspar were similarly exposed. In three days a bright blue change was noticed in the white fluorspar, the "Green John" was slightly darker, and the "Blue John" much darker.

3. Portions of "Blue John" were heated in glass tubes, and thereby decolorised. These decolorised specimens were then exposed to radium and to X-rays. The specimens exposed to radium for fourteen days became a light blue. The specimen exposed to X-rays for about twenty-four hours continuously became dark purple.

4. A small portion of "Blue John," banded, was exposed for six hours to X-rays, and turned almost a dark violet colour.

The "Green John" exposed for fourteen days was distinctly darker in colour.

(B) *Experiments with X-Rays.*

1. Half-an-hour's exposure at 7·5 cm. produced on—
 "Blue John," slight deepening.
 "Green John," no change.
 Fluorspar, change to violet shade.

The fluorspar, on being replaced in a drawer, returned to almost normal colout.

2. Half-an-hour's exposure at 7·5 cm. produced on—
 "Blue John," slight deepening.
 "Green John," no change.
 Fluorspar, change to violet shade.

The fluorspar returned to almost colour.

3. Forty-five minutes' exposure at 7·5 cm. produed on—
 "Blue John," more marked change.
 "Green John," no change.
 Fluorspar, more marked change.

The fluorspar almost recovered.

4. Ten minutes' exposure at 7·5 cm. produced on—
 Fluospar, light violet colour.
 No other change perceptible.

5. Half-an-hour's exposure at 7·5 cm. produced on—
 "Green John," fluorescence.
 Fluorspar, change as before.

The "Green John," after being carried into a dark room, still fluoresced for about three or four minutes.

Fluorspar in a glass tube also fluoresced, but very slightly.

6. Ten minutes' exposure at 7·5 cm. produced on—
 "Green John," slight fluorescence (both).

Material after resting for fourteen days—
 Fluorspar was pink with one mauve spot.
 "Blue John" was darker than when experiments started.
 "Green John" did not appear to have changed at all.

The fluorspar in glass was darker than at first.

None of the specimens exposed to X-rays made any change in photographic plates, even after prolonged exposure.

Even after colour changes had been produced by exposures to X-rays and radium there was no evidence of radio-activity, as shown by exposure of a photographic plate.

From these experiments it appears that there is no substantial difference between white fluorspar and "Blue John," except in respect of the small amount of organic matter which gives the colour of "Blue John."

The same seems to hold for "Green John" and for the amethystine varieties. It appears that the colouring matter is, after all, organic. The influence of X-rays and of radium on natural fluorspar appears similar to that on glass. The *causa causans* is unknown.

From a series of experiments which have now lasted more than two years there is no reason to suppose that what in the earlier trials seemed to be a reasonable hypothesis, namely, that the colour of "Blue John" and other varieties of coloured fluorspar owes its origin to radio-active effect, has any foundation.—*Transactions of the Chemical Society*, cxv., 705.

VACUUM ARC SPECTRA OF VARIOUS ELEMENTS IN THE EXTREME ULTRA-VIOLET.*

By Prof. J. C. McLENNAN, F.R.S.; D. S. AINSLIE, M.A.; and D. S. FULLER, M.A., University of Toronto.

(Continued from p. 92).

6. *Lead.*—The vacuum arc of lead was secured by placing the metal in iron electrodes. A current of 4 amperes was used, and this proved to be sufficient to give an intense arc which was nearly continuous. The measurements of the wave-lengths below λ 2170 A are given in Table VII. Saunders has also measured the vacuum arc spectrum of lead, and his measurements are included in the Table. Where the range is common, the results given in our paper agree fairly well with those of Saunders. His work showed more detail in the region down to λ 2022·64 A, while our work brought out more for the region below that limit. This, no doubt, was due to the fact that the optical system of the instrument used by him apparently included two thin plates of quartz, which would tend to absorb the fainter lines below λ 1850 A. With our system of fluorite the possible attainable limit was well below the range for which the instrument was adjusted.

The arc spectrum of lead was similar to that of tin, in that it included several strong lines well distributed over the range studied in the work. Chemically pure samples of the metal were not obtainable for this work, and hence commercial metal was used, which may have given rise to lines belonging to metallic impurities.

TABLE VII.—*Lead Vacuum Arc Spectrum.*

Intensity.	The Authors. λ (A).	1/λ.	Saunders. λ (A).
8	2170·5	46,072	2170 60
			2112·37
8	2060·5	48,532	
			2053·83
			2022·64
2	1925·8	51,926	
4	1913·7	52,255	
2	1904·2	52,527	1904·88
2	1898 7	52,668	
2	1895·5	52,756	
			1868·59
14	1821 7	54,894	1822·06
10	1796·5	55,664	1796 53
1	1744·2	57,333	
2	1741·1	57,435	
10	1726·2	57,930	1726·71
12	1682 5	59,435	1682·54
12	1671·6	59,823	
3	1597 6	62,594	
12	1555·8	64,276	
4	1511·7	66,150	
1	1494·7	66,903	
1	1492·7	66,993	
5	1434·0	69,735	
5	1431 9	69,837	

* From the *Proceedings of the Royal Society*, A, xcv., 316.

7. *Carbon.*—The carbon vacuum arc spectrum was obtained by using carbon alone as terminals in the vacuum arc lamp. A continuous arc was obtained by using a current of 10 amperes. The spectrum obtained consisted of a line spectrum, the measurements for which are given in Table VIII. A set of poorly defined bands was also observed on our plates, but as the measurements for these were found to be in good agreement with the results of Lyman, they are omitted. In the plates these bands seem to correspond with those of the carbon monoxide spectrum as obtained from a discharge tube. This may have been due to the fact that the carbon arc was at a very high temperature compared to that of the discharge tube. We did not have time, however, to make a detailed study of this point. Very little information has been found available concerning the line spectrum of carbon in the region investigated by us. Comparing our results with those given by Eder and Valenta, two lines at λ 2296·94 A and λ 1930·12 A were found to correspond very well with strong lines obtained in our work. Outside of this there was little similarity, and so their list is not given in full in Table VIII.

TABLE VIII.—*Line Spectrum of Carbon.*

Intensity.	The Authors. λ (A).	1/λ.	Eder and Valenta. λ (A).
2	2307·5	43,337	
9	2298·0	43,516	2296·94
2	2219·0	45,065	
5	2088·5	47,876	
15	1930·5	51,827	1930·12
9	1758·1	56,879	
5	1749·7	57,152	
10	1656·9	60,354	
9	1562·0	64,020	
9	1561·2	64,053	
9	1560·5	64,082	
2	1550·7	64,487	
3	1548·5	64,591	
5	1482·8	67,439	
6	1464·5	68,282	

It was noticed that the wave-lengths λ 1548·5 A, λ 1550·7 A, λ 1656·8 A, and the triplet (λ 1560·5 A, λ 1561·2 A, and λ 1562·0 A) as measured in our work corresponds apparently to the lines λ 1548·2 A, λ 1550·8 A, λ 1656·8 A, and λ 1560·2 A are given by Lyman as lines of uncertain origin. The triplet at λ 1561 A is very prominent, and was present in the spectra of all the metals studied, except that of zinc.

TABLE IX.—*Cobalt.*

Intensity.	The Authors. λ (A).	1/λ.
4	2138·7	46,757
2	2099·3	47,635
5	2061·5	58,503
7	2026·2	49,354
2	1939·5	51,560
9	1929·5	51,827
3	1912·2	52,296
4	1893·8	52,804
10	1861·4	53,721
10	1853·0	53,966
2	1819·8	54,951
1	1740·3	57,461
2	1710·9	58,449
7	1669·0	59,884

8. *Cobalt*—Only small granular pieces of supposedly chemically pure cobalt were available for this work. Using the pieces of metal in iron terminals an intense arc was secured with a current of 12 amperes on closed circuit. Similar to that of iron, the spectrum given by cobalt showed up prominently several lines belonging to carbon. As Eder and Valenta have given a list of wave-lengths down to λ 2173·44 A for the cobalt spark spectrum, which covers the measurements in our work for that region, our results are confined to the wave-lengths below λ 2173·44 A, and these are given in Table IX.

The wave-lengths recorded for the spark spectrum by Bloch and Takamine and Nitta are not included in Table IX. because there does not appear to be a marked similarity between the arc and the spark spectrum for this metal.

(To be continued).

A RAPID METHOD FOR THE DETERMINATION OF FAT IN COCOA AND CHOCOLATE.

By E. B. HUGHES.

The method is based on Bordas' and Touplain's method for the rapid analysis of milk. These chemists have also published a process of this kind for cocoa analysis, but the writer has been unable to find details. The following process, however, is both rapid and accurate. Convenient apparatus is a Leffmann-Beam centrifugal machine fitted with glass cylinders holding about 40 cc.

In the case of chocolate the substance should be ground and passed through a 30-mesh sieve.

To 2 grms. of the finely-powdered substance (1 grm. for whole-fat cocoa) add about 30 cc. of 50 per cent alcohol, mix well, and then whirl and decant off the clear liquid, which is rejected. Again add about 30 cc. of 50 per cent alcohol, stir, whirl, and decant as before.

To the residue after alcohol extraction add 25 cc. of a mixture of equal volumes of ordinary ether and petroleum ether; stir and mix well for about fifteen minutes, whirl, and decant the clear liquid into a tared flask. Again add 25 cc. of ether mixture, stir, whirl, and decant into the flask. Distil off the ether, and weigh the fat in the flask. Two extractions are usually sufficient. The extracted fat is free from impurity.

Results.

A sample of whole-fat cocoa:—

By the centrifugal method ..	44·31 per cent fat
By Soxhlet	44·37 „

A sample of commercial cocoa:—

By the centrifugal method ..	21·15 per cent fat
By Soxhlet (*a*)	20·85 „

A sample of chocolate:—

By the centrifugal method ..	31·55 per cent fat
By Soxhlet (*a*)	31·50 „

(*a*) The extracted fat was impure and had to be taken up again in ether.

THE MANUFACTURE OF FERMENTATION GLYCERIN IN GERMANY DURING THE WAR.

The investigations initiated by Lüdecke with the object of obtaining glycerin on an industrial scale by means of the fermentation of sugar assumed supreme importance in Germany after the outbreak of war, when the supplies of fat became enormously curtailed as a result of the imposition of the blockade. The extension of these researches and the conversion of the results obtained into the practical process of Connstein and Lüdecke were kept a close secret during the war, but were recently made known by Connstein at a meeting of the German Chemical Society, a report of which has appeared in the *Wochenschrift fur Brauerei* (May 10, 1919).

The process is based on the observation that the percentage of glycerin formed from sugar is increased if the fermentation is allowed to proceed in presence of alkaline substances. Among the latter a special position is

occupied by sodium sulphite, which yeast is able to withstand in very large proportions. Thus a solution prepared from 10 litres of water, 1 kilo. of sugar, and 400 grms. of sulphite, together with ammonium sulphate, sodium phosphate, and potassium salts, is completely fermented in a few days by 100 grms. of yeast.

The process was worked by the Protol Company, and as many as 63 factories were at first pressed into the service, although only the few largest were finally retained, the monthly output of glycerin being about 1000 tons. Very serious practical and administrative difficulties were encountered at the outset, but these were ultimately overcome, and it was found possible to obtain 20 parts of purified glycerin, 27 parts of alcohol, and 3 parts of aldehyde from 100 parts of sugar. After removal of the yeast by filtration and of the alcohol and aldehyde by distillation, the bulk of the salts present are precipitated by calcium chloride and then by sodium carbonate, the liquid being afterwards neutralised with hydrochloric acid and filtered from the sludge formed; concentration and subsequent distillation yield a glycerin suitable for all technical purposes. As is the case with soapworks glycerin, the distillation of fermentation glycerin is sometimes complicated by the presence of trimethyleneglycol.

Neither the race of yeast, nor the nature of the sugar, nor the temperature prevailing during fermentation influences the yield of glycerin; raw sugar or even molasses is utilisable. At the termination of the fermentation the yeast exhibits certain changes in its morphological character, but still retains its fermentative capabilities; the worts used are, however, fatal to lactic and acetic bacteria.

With increase in the amount of sodium sulphite employed, the proportions of glycerol and aldehyde produced gradually increase, whilst those of alcohol and carbon dioxide continuously diminish; this is illustrated by the following experimental figures:—

Sulphite employed ..	25	50	100
Glycerin formed	11·3	19·6	27·1
Alcohol formed	40	28·7	23·3
Aldehyde formed	2·4	5·8	8·6
Carbon dioxide formed..	37·6	35·8	29·4

No information is available as to the cost of fermentation glycerin, and its economic manufacture in normal times would naturally depend on such questions as prices, supply of fats, &c.—*Journal of the Society of Chemical Industry*, xxxviii., No. 15.

PRECIOUS STONES IN THE UNITED STATES.*

The value of the precious stones annually produced in the United States from the beginning of this century to 1914 has been about one-third of a million dollars. In 1914 and in every year since, the annual value of the output has dropped considerably, and in 1918 it dropped to 106,523 dols., the lowest reported since the United States Geological Survey began to collect statistics of gem production, in 1883, with the single exception of 1896, when it was 97,850 dols.

The report on the production of precious stones in 1918, just published by the Survey, ascribes the decrease in the value of the precious stones produced to the military enlistment of many gem miners, the general scarcity of labour, and the poor market.

The output consisted chiefly of the sapphire variety of corundum, which is nearly all used as mechanical bearings in watches and other instruments that require practically non-wearing frictionless bearings. Other less valuable and softer minerals used for this purpose are garnet and some forms of hard compact silica, known as agate and chalcedony. The annual value of the output of the four gem minerals, corundum, quartz, tourmaline, and turquoise, amounts to over four-fifths of the total value of all the precious stones produced in the United States.

* U.S. Geological Survey. Press Bulletin, July, 1919.

Montana, Nevada, California, Colorado, Maine, and Arizona are the chief gem-producing States, but from 20 to 30 States annually report some production.

Several relatively large diamonds were found in Arkansas in 1918, notably a canary-coloured octahedron weighing nearly 18 carats and a number of smaller stones weighing several carats each. The value of all the diamonds produced in the United States, however, in no year exceeds a few thousand dollars.

The report also records the finding of two large diamonds in South Africa, weighing about 3 ounces each. It is estimated that about half the diamonds in the world are owned in the United States, and that their value is over a billion dollars. With the elimination of competition from German South-west Africa 95 per cent of the world's production of diamonds will be under the control of the De Beers Consolidated Mines Co. and its selling agents.

The report gives a short list of the industrial uses of precious stones of gem quality and full descriptions of the Iceland spar variety of calcite and of optical fluorite, states the special uses and necessary qualifications of the material, and includes lists of buyers.

The report on the production of precious stones in 1917 contains a full list of gem names, each followed by the name of the mineral species to which the gem belongs. A second list gives names of the mineral species, each followed by all the names of the corresponding gem.—*Journal of the Franklin Institute*, clxxxviii., No. 2.

BOARD OF TRADE ANNOUNCEMENTS.

The Profiteering Act.

The Profiteering Act, which became law on August 19, authorises the Board of Trade to make orders applying the Act to any article or class of articles declared by the Board to be articles of a kind in common use by the public, or material, machinery, or accessories used in the production of such articles.

It is the intention of the Board that the provisions of the Act should be administered by means of Committees or Tribunals, and for this purpose it is proposed to establish three grades of Committees or Tribunals, Central, Local, and Appeal.

Central Committee.—The Board of Trade is establishing the Central Committee. This body will be presided over by Mr. C. A. McCurdy, K.C., M.P., Parliamentary Secretary of the Ministry of Food and Chairman of the Committee on Trusts. He will be assisted by such Deputy Chairmen as may be necessary. These will be appointed by the Board of Trade. The Associated Chambers of Commerce, Associations of Employers, Representatives of the Co-operative Movement, and Representatives of Employees, including Trade Unions, are being invited to suggest names of persons suitable for appointment as members of the Committee.

In general, the functions of the Central Committee will be to investigate cases of alleged profiteering by persons other than retail traders, and when necessary to institute prosecutions. In pursuance of this duty it will itself collect information as to prices, costs, and profits, and will study the methods and practices of the various trades or groups of trades, including Trusts and Trade Combinations concerned in the production and distribution of goods to which the Act is applied.

In order that the Central Committee may be in a position to advise the Board of Trade as to what may be considered a reasonable price for any article, it will be empowered, should necessity arise, to appoint Sub-Committees to carry out the investigation into the cost of production throughout the various stages of manufacture.

Local Committees.—It is proposed that the Local Authorities, that is to say, in England and Wales, the Common Council for the City of London and the Councils of the Metropolitan and Municipal Boroughs, and of the Urban and Rural districts, and the Council of the Scilly Isles, and in Scotland; the Councils of the County and the Councils of the Royal, Parliamentary, or Police Boroughs, should be invited to appoint Local Committees in accordance with regulations made by the Board of Trade.

To these the Board of Trade will delegate power to investigate and hear complaints of alleged profiteering on the part of local retailers, and either to dismiss the complaint or to declare the price which would yield a reasonable profit, and require the seller to repay to the complainant any amount paid by the complainant in excess of such price. It is provided by the Act that the expenses of these Committees will be defrayed by the Local Authorities out of local funds or rates.

The President of the Board of Trade is anxious to encourage the formation of Local Committees, and hopes that every Local Authority will apply for powers to establish such a Committee. The decision whether any Local Committee shall be appointed for a district rests, however, with the Local Authority, and in the event of any Local Authority failing to appoint a Committee it is not the present intention of the Board of Trade to appoint a local Committee for that district.

Appeal Tribunals.—It is intended that Appeal Tribunals to hear appeals from the decisions of the local Committees as provided by the Act, will be appointed for each county or groups of counties in England and Wales by the Board of Trade. Chairmen of County Councils in England and Wales are being invited to convene meetings of representative people to suggest to the Board of Trade the names of suitable persons for membership of these Tribunals. The Secretary for Scotland is being asked to undertake on behalf of the Board of Trade the formation of Appeal Tribunals for Scotland. The Irish Government is being consulted as to the application of the Act to Ireland.

It will be seen that two separate and distinct lines of action are contemplated:—

Central Investigation by the Central Committee into the cost and profits of production and distribution of goods to which the Act has been applied.

Local Investigation by Local Committee (subject to appeal as provided by the Act to Appeal Tribunals) into such complaints as may be made by members of the general public concerning the prices charged and the profits made in the retail distribution of goods to which the Act has been applied. In any case in which investigation discloses actual profiteering, prosecution may follow.

It will be an instruction of the Board of Trade to all Committees and Tribunals established under the Act that no action shall be taken which will hamper or restrict legitimate commercial enterprise throughout the country. It is not the intention of Parliament as expressed in the Act to prevent any person or company from making a reasonable profit on their business transactions.

COASTWISE TRADE.

In consequence of the withdrawal of coastwise steamers a large volume of traffic has been diverted from sea to rail with the result that the railways are now burdened with traffic which they have not previously carried. The absence of normal coastwise shipping facilities is impeding the transport of the food supplies of the Nation, of the raw materials needed in our mills, factories, and workshops, and of our manufactures for export, and thereby the cost of living is advanced, the re-establishment of our industries and commerce is retarded, and the difficulties of finding employment are increased.

In these circumstances there is urgent necessity to relieve the railways of such traffic as can reasonably be carried coastwise.

The continued application of pre war rates to the carriage of goods by rail offers strong monetary inducements to traders to use the railways for all goods, including those which can be sent forward as conveniently coastwise, but the unrestricted use of the railways is interfering with the flow of traffic through the Ports and thereby placing limitations on both imports and exports.

There is therefore urgent necessity to use to the full the coastwise services, but they can only be re-established on a pre-war footing by being assured of a reasonable amount of regular traffic. Full services cannot be maintained if they have to depend on the carriage of casual traffic which is from time to time shut out by the railways.

To meet these difficulties the War Cabinet have given directions to the railway companies that no goods which have been imported foreign, or which are intended for export foreign, shall be carried by rail between points which can be effectively served in whole or part by coastwise carriage. For this purpose schedules of traffic will be prepared by the Home Trade District Transport Committees in consultation with representatives of the railway companies on those Committees, and all goods included in such schedules (whether transhipment goods or otherwise) will be carried, in whole or part, coastwise at the freights and charges then current, and on the terms and conditions set forth in the sailing bill, conditions of carriage and/or bill of lading form then in common use for other similar cargo carried coastwise.

The difference between the freights and charges so paid (other than demurrage) and the amount of the railway rates and charges which would have been payable if the traffic had been carried by rail will be refunded by the Railway Executive Committee or their agent to the trader by whom the payment has been made. All applications for refunds must be lodged within three months of date of forwarding of the traffic.

All persons having goods to forward under this arrangement must lodge an application in a form annexed with the Home Trade District Transport Committee for the district from which the goods will be consigned, and must follow the directions given by that Committee as to the route and means by which the goods are to be forwarded.

Traders will greatly facilitate the prompt carriage of goods by lodging their application forms at least ten days before the goods will be ready for shipment.

The districts for which Home Trade District Transport Control Committees have been appointed, and the address of each of such Committees to which all communications are to be sent, may be obtained.

This arrangement is entirely of a temporary nature, and subject to termination at any time.

PROCEEDINGS OF SOCIETIES.

FARADAY SOCIETY.

Ordinary Meeting, July 14, 1919.

Prof. ALFRED W. PORTER, F.R.S., Vice-President, in the Chair.

THE CHAIRMAN gave expression to the great loss physica science had sustained by the death of Lord Rayleigh, who for many years had been a Vice-President of the Society, and a vote of condolence was passed to Lady Rayleigh and the other members of the family.

The following papers were read and discussed:—

"Method of Measuring the Magnetic Hardness of Ferrous Metals and its Utility for carrying out Research Work on Thermal Treatment." By L. A. WILD.

"The Electrolysis of Solutions of Sodium Nitrate using a Silver Anode." By F. H. JEFFERY, M.A.

"The Disappearing Filament Type of Optical Pyrometer." By W. E. FORSYTHE, of the Nela Research Laboratory, Cleveland, U.S.A.

"On some Chemically Reactive Alloys." By E. A. ASHCROFT.

"On a Theory of Invar." By Prof. H. HONDA and H. TAKAGI.

"On the Equation for the Chemical Equilibrium of Homogeneous Mixtures. Part I. Equilibrium at Constant Temperature." By Prof. ALFRED W. PORTER, F.R.S..

"The Mechanism of the Surface Phenomena of Flotation." By IRVING LANGMUIR. Communicated by E. HATSCHEK.

CORRESPONDENCE.

CANADIAN PRODUCTS.

To the Editor of the Chemical News.

SIR,—An editor has suggested to me that the Canadian Mission may be willing to secure from Canada special articles by leading authorities dealing with special branches of trade and industry. The suggestion is so good in my judgment that I submit it to you with the promise that I shall be only too happy to help secure such articles, if from time to time you would be willing to put your requests before me.—I am, &c.,

SYDNEY WALTON.

Canadian Mission,
1, Regent Street, London, S.W. 1.

[The Editor will be pleased to deal with matters suggested in this letter, or inquiries may be made direct to the Canadian Mission as addressed].

NOTES.

FROM the "Annual Report of His Majesty's Inspectors of Explosives," recently published, it appears that during the period of the war from August 4, 1914, until November 11, 1918, the number of accidents which occurred in factories licenced under the Explosive Acts, was 1277, in which 1316 persons were injured and 325 killed. Although at the first glance the loss of 325 lives and injuries to 1316 workers may seem unduly large, yet when these figures are distributed over four and a quarter years, the net result works out at 76·5 persons killed and 310 injured per annum, or, taking the average number of workers employed, only 1·25 persons killed and 5 injured per 1000 per annum. In the year 1910, the last occasion prior to the war on which we obtained corresponding figures, the average number of fatalities for the previous period of five years was 1 per 1000 per annum, so that having regard to the output produced at high pressure, largely by workers with no previous experience, supervised in many cases by equally inexperienced officials, the general result may be regarded as satisfactory. Several interesting points may be noted in connection with these figures. In the first place, out of a total of 1277 accidents, no less than 544 caused no personal injury. In the manufacture of detonators this immunity is particularly remarkable in that the explosion of even one of these dangerous articles is in ordinary circumstances sufficient to cause serious injury to the operator, whereas more than half of the 209 accidents in this manufacture, owing, no doubt, to the special protection given, injured no one. Secondly, of the 325 deaths, 177 were due to T.N.T., picric acid, and di-nitrophenol, representatives of a type of explosive which prior to the vast experience of the war was universally regarded as comparatively free from danger. In the filling of over 83 millions of hand grenades no fatal accident occurred.

ARTIFICIAL STONE FROM MICA AND CLAY.—Mr. Chr. Ingvaldsen, of Saabeim, Norway, claims to have devised a process of making a practicable building stone by mixing finely divided mica with a just sufficient amount of clay or other substance of similar properties to form a coherent mass, which is then shaped into blocks, plates, and other objects of any desired shape and size. These, it is learned, are then fired at a temperature just high enough to fuse the mass, the resulting stone having in general the same properties as natural mica. If it be desired to produce stone having greater resistance to high temperatures, the process is modified as follows:—Instead of mica alone, a mixture of equal parts of mica and of crushed quartz, with just enough clay to act as a binder. The stones formed from this mixture are fired at a temperature high enough to secure the fusing of the mica. The result is a homogeneous mass not only highly refractory to heat, but capable of acting as an electric insulator.—(*American Architect; Journal of the Franklin Institute*, July, 1919). —*Technical Supplement.*

REACTION PRODUCTS OF ALKALI-SAWDUST FUSION.—The formation of oxalic acid by fusion of sawdust with sodium or potassium hydroxides, or both, was discovered long ago. But the earlier investigators say very little about other products found by the action of alkali on sawdust. The growing demand for acetic acid has led to a search for new sources of this important chemical. An investigation was undertaken by the authors of this paper, S. A. Mahood and D. E. Cable, to ascertain the amount of acetic acid obtainable from various species of wood, in the form of sawdust, by fusion with alkali, a treatment which gives the largest yield of acetic acid. Hardwood sawdust was used principally, because it is less suitable for the production of ethyl alcohol, and also because the hard woods give larger yields of acetic acid on destructive distillation. The runs were made chiefly on oak, elm, and maple. The methods of treatment and apparatus used are described in detail, and the results set out in tabulated form, much information of practical value being embodied in these descriptions. The outcome of the investigation is given in a summary, from which we learn that from 17 to 20 per cent of acetic acid can be obtained from hard wood sawdust by fusion with sodium hydroxide. There is a simultaneous production of oxalic acid amounting to approximately 50 per cent of the dry weight of the wood. When the reaction is carried out in a closed vessel there is also simultaneous production of methyl alcohol amounting to 2·4 per cent. But, as the temperature is increased beyond 200 degrees, the yield of oxalic acid is considerably reduced. At lower temperatures, both formic and acetic acids are produced amounting to about 15 per cent each. It appears that the yields of oxalic acid obtained with caustic soda more nearly approached those obtained with caustic potash when the temperature is kept at about 200 degress, the heating prolonged, and the ratio of alkali to sawdust maintained at 3 to 1. An important fact is that it has been found possible to recover as much as 91 per cent of the alkali used.—(*Journal of Industrial and Engineering Chemistry*, July, 1919).—*Technical Supplement.*

INSTITUTION OF MINING ENGINEERS.—The Thirtieth Annual General Meeting will be held at Birmingham on Wednesday, September 10, 1919, at 11 a.m., in the Medical Theatre of the University of Birmingham, Edmund Street, Birmingham. The members will be welcomed to the City by Sir Oliver Lodge, D.Sc., LL.D., F.R.S., Principal of the University of Birmingham, and by the President (Mr. William Charlton), of the South Staffordshire and Warwickshire Institute of Mining Engineers. The members will dine together on Wednesday, September 10, at the Grand Hotel, Birmingham. A reception by the Lord Mayor of Birmingham (Sir David Brooks, G.B.E.) and Lady Brooks will be held at the Council House, Birmingham, on the evening of Thursday, September 11. Arrangements have been made for visits to places of interest and works on September 11 and 12. Ladies are cordially invited to attend the dinner and reception, and to take part in excursions. Further pa:

ticulars can be obtained from L. T. O'Shea, Honorary Secretary, and Percy Strzelecki, Secretary, Albany Buildings, 39, Victoria Street, Westminster, S.W. 1.

With regard to the points raised by the Prime Minister in his speech on Monday, August 18, Sir Vincent Caillard, President of the Federation of British Industries, makes the following statement:—The Federation are in entire agreement with the Prime Minister in his description of the industrial situation. It is vital that every one must pull together, both employers and employed, disabusing their minds of the suspicions which, to some extent, still exist unfortunately. The whole community must act in that splendid spirit which animated all classes during the war. The matter is not merely an employers' question, or a workers' question, but a matter concerning all. It is certain that members of the Federation of British Industries will do everything which lies in their power to answer the urgent national call. Everything depends upon production, which in turn depends largely upon the method in which such questions as the future trade policy of the country and nationalisation are dealt with. So far as the mining industry is concerned, it is impossible to give any definite views on so general a statement as that made by Mr. Lloyd George, but the rough outline given by the Premier will doubtless appear to the great body of sensible opinion. Particularly with regard to the removing of import restrictions, everything must depend upon the measures taken by the Government with regard to anti-dumping and protection to be afforded to important industries. It is thought regrettable that the Government have not taken definite action in these matters before removing the import restrictions, as manufacturers and producers are left in a state of doubt as to what the future will be, and there is considerable risk in spite of the automatic protection which the Premier stated was given by exchanges and freights, that production will be disorganised to a great extent and unemployment consequently increased, till such time as Parliament can pass definite measures to meet the situation.

TO CORRESPONDENTS.

A correspondent asks for name of the makers of best palmitin (melting-point 38°) and absolute creosoti.

Analytical Chemist seeks Appointment. B.Sc. (Lond.), First-class Hons. in Chemistry, A.I.C. (Branch e), 1917. Pharmaceutical Chemist where general Analytical knowledge, exclusive of Metallurgy, is required.—Address, P. C., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

B.Sc. (Vict.), 1919, desires Position as Assistant Chemist in Lancashire. Degree subjects: Chemistry and Botany, with Zoology (inter.). Some Works experience (during vacations), Nitric and Sulphuric Acids.—Address, Miss V., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist, three years' experience in large Tar Products Works before taking active service, now demobilised, desires Employment in London or the Provinces.—Address, T. T., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist, recently demobilised, three years' Technical College training and one year's Works experience, desires to communicate with firms as to suitable Appointment.—Address, O. C., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Laboratory Assistant (Girl 21), Inter. B.Sc. standard, desires Employment in any branch of Chemistry. In or near London. Very keen. References if necessary.—Address, A. M., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Lady Chemist (25) desires change of post, preferably in or near London. B.Sc. Hons. in Chemistry. Three years' Analytical experience.—Address, S. M. K., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

TO BE SOLD.

From the LABORATORY of the late Sir WILLIAM CROOKES, O.M.

Two SIEMENS DYNAMOMETERS, reading from 0·1 Amp. to 50 Amp.

BECQUEREL PHOSPHOROSCOPE, in case.

KRYPTOL ELECTRIC FURNACE, with stock of granulated carbon.

RESISTANCE BOX, 1 to 5000 ohms, by Elliott.

POST-OFFICE BRIDGE, by Elliott.

DUBOSCQ ELECTRIC LAMP.

CHEMICAL BALANCE, by Kiessler.

Two COMPOUND MAGNETS.

"CRAWFORD MILL" GOLD AMALGAMATING MACHINE.

MAHOGANY WHOLE PLATE CAMERA, with three double dark slides, Ross lens, Eastman roll holder slide and stand.

CAMERA LUCIDA, by James Howe, in case.

LECTURER'S PROJECTION LANTERN, with extra condensers and three lenses of different powers, automatic electric lamp, complete in case.

About 1 cwt. of cored ARC LAMP CARBONS, 12 mm. in diameter and 10 inches long.

Quantity of miscellaneous LABORATORY APPLIANCES.

Can be Seen by Appointment.

Address in first instance, W. S. C., Chemical News *Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.*

Wanted, Laboratory SECK MILL, New or Second-hand. Supply particulars.—Address, S. M., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

BOROUGH OF ROCHDALE.

GAS DEPARTMENT.

The Gas and Electricity Committee of the above Corporation invite applications for the Position of GAS WORKS CHEMIST and Superintendent of the Tar and Sulphate Works connected with the Gas Works

Applicants must have had practical experience in the management of Tar and Sulphate Works and be competent to undertake all the necessary Analyses in connection with those Works, and also such as may be required in the ordinary work of the Gas Department.

The person appointed will be required to devote the whole of his time to the duties of the position.

Applications, endorsed "Chemist," stating salary required and accompanied by not more than two recent testimonials, must be addressed to Mr. T. Banbury Ball, the Engineer at the Gas Works, Rochdale, and must be sent in before noon on Wednesday, September 3, 1919.

(By Order) WM. HENRY HICKSON,
Town Hall, Rochdale, Town Clerk,
August 14, 1919

THE CHEMICAL NEWS

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HOW THE NITROGEN PROBLEM HAS BEEN SOLVED.*

By HENRY JERMAIN MAUDE CREIGHTON, Department of Chemistry, Swarthmore College, Member of the Institute.

(Continued from p. 101.

III. THE ABSORPTION OF NITROGEN BY CARBIDES—THE CYANAMIDE PROCESS.

IN 1894 the attention of the technical world was focussed upon the invention of Moissan and Wilson, which led to the manufacture of calcium carbide in the electric furnace on a large scale. A short time afterwards Frank and Caro made the discovery, that while barium carbide could readily be made to combine with atmospheric nitrogen at high temperatures to form barium cyanide, but small quantities of cyanide could be formed with calcium carbide under the same conditions, notwithstanding the fact that there was apparently a large absorption of nitrogen. This striking result led to a closer examination of the reaction product, and it was found that most of the nitrogen absorbed by the carbide had been converted into calcium cyanamide. From a technical standpoint the absorption of nitrogen by calcium carbide at high temperatures is of the greatest significance, and constitutes one of the most important means for the fixation of atmospheric nitrogen.

Outline of the Principles Underlying the Formation of Calcium Cyanamide from Calcium Carbide and Atmospheric Nitrogen.

Although the reaction between calcium carbide and nitrogen is usually expressed by the simple reversible equation—

$$12.\quad CaC_2 + N_2 \rightleftarrows CaCN_2 + C,$$

in reality it is so complicated that up to the present all attempts to establish its equilibrium constants have been unsuccessful. If calcium carbide, calcium cyanamide, and carbon are regarded as solid phases, the system should be monovariant, and there should be a definite pressure corresponding to a given temperature. Should the pressure exceed this equilibrium value, then nitrogen must be absorbed by the carbide, while if the pressure should be less than this value, then calcium cyanamide must react with the carbon to re-form calcium carbide and nitrogen.

Attempts to measure the equilibrium of the reaction have produced very conflicting results. Thus, the equilibrium temperature corresponding to a pressure of one atmosphere is given as 1700° C. by Thompson and Lombard, as 1360° C. by Caro, and as 1100° by Matignon. This lack of agreement has been ascribed to a number of different causes, among which may be mentioned the chemical inertness of nitrogen; the impurities present which probably take part in the reaction; the disturbance of the equilibrium caused by sublimation of the calcium cyanamide; and still more fundamental, the fact that probably during the reaction calcium carbide dissociates into carbon and a lower carbide.

The azotisation of calcium carbide is a strongly exothermic reaction. So much heat is liberated during the initial stages of the reaction that the reaction mass is raised to between 1000° C. and 1100° C., the temperature necessary for satisfactory azotisation.

The rate at which nitrogen is absorbed by commercial calcium carbide varies with the temperature at which azotisation takes place, a temperature of at least 1000° C. being necessary for rapid and complete azotisation. Below this temperature the absorption of nitrogen is limited and takes place slowly. The influence of temperature on the rate of absorption is illustrated graphically by the full curves in Fig. 12, for nitrogen under a water pressure of 132 mm. The rate of azotisation also increases with the pressure up to about two atmospheres, but further increases in pressure produces little change in the rate at which the gas is absorbed.

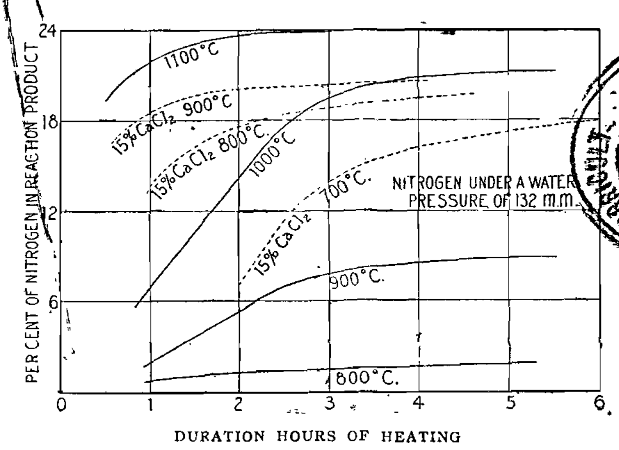

FIG. 12.

Moissan has shown that pure calcium carbide is quite inert towards nitrogen at a temperature of 1200° C. The ease with which the commercial carbide absorbs nitrogen at this temperature is due to the presence of 10 to 15 per cent of lime and other impurities which act as catalysts.

It has been found that if certain substances are admixed with commercial calcium carbide the rate of azotisation is markedly increased, and the minimum initial reaction temperature is lowered. For metals of the same periodic group the acceleration is greater the lower the atomic weight. Of the many addition substances studied the most effective is calcium chloride, as is shown by the data contained in Table VIII., in which is given the per cent of nitrogen absorbed in two hours at 800°.

Calcium chloride lowers the reaction temperature to such an extent that a rapid absorption of nitrogen takes

* From the *Journal of the Franklin Institute*, April, May, and June, 1919.

place at temperatures from 700° C. upwards. The rate of absorption increases with the content of the chloride up to 30 per cent, although its effect becomes less marked as the percentage increases. With calcium fluoride the reaction temperature is not brought so low as in the case of the chloride, and an addition of from 2 to 5 per cent is most favourable. The rate of azotisation of calcium carbide at different temperatures in the presence of 15 per cent of calcium chloride is shown by the broken curves in Fig. 12.

Table VIII.

Addition substance.	Per cent nitrogen absorbed.
None	3·2
10 per cent CaO	4·0
10 per cent Na_2CO_3	8·5
10 per cent NaCl	13
10 per cent $CaCl_2$	22

The ultimate cause of the increased azotisation of calcium carbide by these addition substances (including the lime always present in the commercial carbide) is probably due to their assisting the reaction by the removal of the film of calcium cyanamide from the carbide, and to their softening the reaction mass, thus increasing its power of taking up nitrogen. The immediate cause is more obscure, but is probably related to the rate of decomposition of the carbide into carbon and a sub-carbide,

$$13.\ CaC_2 \rightleftarrows CaC+C,$$

and the absorption of nitrogen by the latter,

$$13a.\ CaC+N_2 \rightleftarrows CaCN_2.$$

The Technical Production of Cyanamide.

(Note.—In this paper the term "cyanamide" is used to denote the commercial product, the chief component of which is $CaCN_2$, and not to denote the compound $CN.NH_2$).

The calcium carbide employed in the manufacture of cyanamide is prepared from lime and coke in the electric furnace, and is usually about 80 per cent pure. After cooling, the carbide is ground in air-tight apparatus filled with nitrogen, so that it passes a hundred-mesh screen. As carbide of this fineness is almost as explosive as low-grade dynamite when exposed to the atmosphere on a damp day, the operation of grinding presents a problem.

The nitrogen used in the manufacture of cyanamide is obtained at the present time either by the fractional distillation of liquid air or by the copper oxide process. As the gas must be of a high degree of purity, it has to be freed from water vapour, the oxides of carbon, and oxygen. On no account should the oxygen present exceed 0·4 per cent. Water vapour and oxygen react with the carbide and the carbon resistances of the furnace, in accordance with the following equations:—

$$14.\ 2C+O_2=2CO;$$
$$15.\ C+H_2O=CO+H_2;$$
$$16.\ CO+CaC_2=CaO+3C;$$
$$17.\ H_2O+CaC_2=CaO+C_2H_2;$$
$$18.\ 3O_2+2CaC_2=2CaO+4CO.$$

The finely ground carbide is transferred to iron retorts having a capacity of from one-half to two and one-half tons. By employing small units a uniform temperature and, therefore, a more reliable product, can be obtained. The retorts are next placed in the "furnace," consisting of a gas-tight, horizontal channel, the roof of which is removable to allow of the handling of the retorts. Pure nitrogen is then admitted into the channel of the furnace under a pressure slightly in excess of one atmosphere, so as to overcome any tendency of air to enter.

The retorts are heated electrically by means of carbon resistances. Each retort contains a central carbon-rod, or several connected in series. When the retorts are in position the resistances are connected electrically to suitable permanent terminals in the furnace. With the electric method of heating, difficulties arising from strong sintering of the material and its adhesion to the walls of the retort are avoided.

After all the air has been expelled from the retorts the electric current is turned on. Each retort requires from 65 to 75 volts. It is probable that a number of units are connected in parallel, and that a low current, *e.g.*, 20 amperes, is employed. The retorts are heated for thirty or forty hours, during which time the temperature in the outmost layers of the reaction mass rises to about 1000° C. The current is then interrupted and the reaction allowed to complete itself, the end being indicated by the pressure registered by a manometer in the nitrogen pipe-line.

The crude cyanamide when taken from the furnace usually contains 63 per cent calcium cyanamide, corresponding to 22 per cent nitrogen, 12 per cent lime, 12 per cent carbon in the form of graphite, 1 per cent unazotised carbide, 1 per cent calcium sulphide, 2 per cent iron and alumina, and 2 per cent silica. On cooling, the cyanamide is ground in an atmosphere of nitrogen to a fine powder. During this operation great precautions are taken to prevent explosions due to the presence of acetylene derived from the unazotised carbide.

Production of Ammonia from Cyanamide.

On treating cyanamide with superheated steam ammonia is produced in accordance with the equation—

$$19.\ CaCN_2+3H_2O=CaCO_3+2NH_3.$$

Under proper conditions the reaction is almost quantitative. The rate at which ammonia is formed increases with temperature, as is shown by the data in Table IX.

Table IX.

Temperature ° C.	Per cent nitrogen converted into ammonia at the end of— 15 minutes.	45 minutes.
120°	11·3	31
160°	45·8	83·7
180°	75·2	—

The reaction follows the monomolecular equation, the velocity constant at different temperatures having the following values:—0·00362 at 120° C., 0·0046 at 130° C., 0·00687 at 140° C., 0·0111 at 150° C., 0·0177 at 160° C., 0·027 at 170° C., and 0·0403 at 180° C.

The reaction is exothermic, and the heat developed is sufficient to cause the process to proceed of itself at a high velocity when once it has started. In order to take advantage of this heat development the reaction is carried out in steel autoclaves, 8 feet in diameter and 20 feet high, capable of operating under a working pressure of 300 pounds per square inch. In each autoclave is placed about 12,000 pounds of mother-liquor derived from a previous operation (fresh water to start), and the finely ground cyanamide slowly fed into this liquor under continuous agitation by a powerful stirring apparatus with which each autoclave is provided. Any acetylene evolved during this operation is removed by a suitable ventilating system. In order to insure thorough incorporation of the cyanamide, the charging of the autoclaves is usually carried out over a period of an hour. Lime and soda are next added. These substances increase the efficiency of the ammonia evolution, principally through the prevention of the formation of polymeric forms of cyanamide compounds which are difficult to transform into ammonia. The autoclaves are then closed and superheated steam admitted until the pressure gauge registers 3 or 4 atmospheres. The temperature is then sufficiently high to start the reaction at a fair rate of speed, after which it proceeds of itself. As the temperature rises the gas pressure is relieved by means of valves through which the gas is discharged, the

rate being so regulated as to maintain a constant pressure on the ammonia line. The evolution of ammonia usually continues for about one and one-half hours. While nearly all of the cyanamide is decomposed during this operation, the steaming is usually repeated a second, and even a third time.

The ammonia-steam mixture which comes from the autoclaves is passed through a simple rectifying column provided with a dephlegmator and condenser, from which is obtained ammonia, saturated with water vapour, having a very high degree of purity.

Production, Energy Requirements, and Costs.

During the past few years the production of cyanamide has increased very rapidly, furnishing in 1918 about one-fifth of the world's fixed nitrogen. The present annual producing capacity of different countries is as follows.

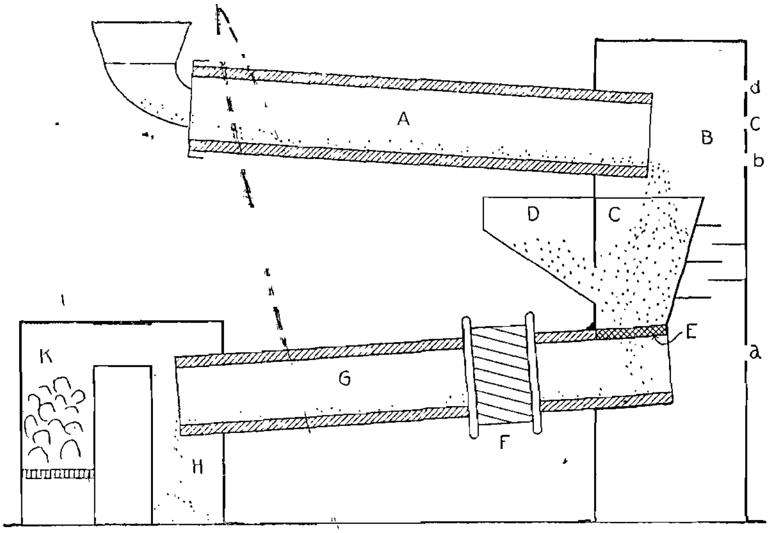

Fig. 13.—Diagrammatic Representation of Serpek Apparatus.

(The writer wishes to acknowledge his indebtedness to Mr. E. J. Pranke, of the American Cyanamide Company, for the figures).

Germany	500,000 tons
France	300,000 tons
United States (Muscle Shoals)	220,000 tons
Norway and Sweden	220,000 tons
Canada (Niagara Falls).. ..	64,000 tons
Italy	60,000 tons
Japan	50,000 tons

Aside from the preparation of nitrogen, the electrical energy requirements in the manufacture of cyanamide amount to 16·6 kilowatt hours per kilogrm. of nitrogen fixed, or to 1 kilowatt hour per 100 grms. of cyanamide produced. The cost of conversion of cyanamide to ammonia has been estimated (on a pre-war basis) at one and one-half cents per pound of ammonia, and the total cost of ammonia by the cyanamide process, with power at 8 dols. per horse-power year, at 1 to 2 cents more than by the Haber process.

Advantages and Disadvantages.

The chief advantages of the fixation of atmospheric nitrogen by carbides, as represented by the cyanamide process, are:—

1. Moderate power requirements.
2. Easy transportability.
3. Product may be used as a fertiliser or for the production of ammonia of a very high degree of purity.

The chief disadvantages of the process are:—

1. Number of operations involved, especially if it is required to produce nitric acid, viz., production of carbide, production of pure nitrogen, production of cyanamide, decomposition of cyanamide to ammonia, oxidation of ammonia, absorption of nitrous gases, and the concentration of dilute nitric acid.
2. Process is extremely dusty and disagreeable.
3. Large labour factor involved.
4. Comparatively high cost.

IV. The Absorption of Nitrogen by Metals in the Form of Nitrides.

Since many metals, such as titanium, aluminium, lithium, magnesium, &c., readily combine with nitrogen to form nitrides from which ammonia is easily obtained, this class of compounds has been extensively studied during recent years, with a view towards determining whether they could be employed for the commercial fixation of atmospheric nitrogen.

The normal nitride of titanium, TiN_2, on being heated in a current of hydrogen, yields nearly one-half of its nitrogen in the form of ammonia. The residual lower nitride, TiN, on being heated in an atmosphere of nitrogen is converted back into the normal nitride. Repeated attempts have been made in France to build up an industrial process for the manufacture of ammonia on the basis of this reaction, but without success. Some years ago H. B. Landmark claimed to have perfected a continuous process for the manufacture of ammonia from this nitride, based upon the reaction expressed by the equation:—

$$20.\quad 2TiN_2+3C+3H_2O \rightleftarrows 2TiN+3CO+2NH_3.$$

Steam is passed over a heated mixture of the nitride and carbon. By substituting a current of nitrogen for steam the normal nitride is regenerated; by employing a current of steam in place of the nitrogen the operation becomes continuous, requiring from time to time a renewal of the supply of carbon. Essentially the titanium acts as a catalytic agent.

Ottokar Serpek was the first to recognise the possibility of applying the reaction between aluminium and nitrogen to the fixation of atmospheric nitrogen. The manufacture of aluminium nitride has received considerable attention because of the ease with which it can be converted into ammonia, and because of the possible importance for the

aluminium industry of the alumina obtained as a by-product. Indeed, this is the only process depending on the formation of a metallic nitride which, at the present time, seems to offer prospects of technical success for the fixation of atmospheric nitrogen. Though the process was in operation in a small way at Saint Jean de Maurienne, in Savoy, and two large semi-commercial installations are at present being tested in this country, at the present time it must be regarded as an unproven process.

The Technical Production of Aluminium Nitride by the Serpek Process.

In the Serpek process, aluminium nitride is prepared from bauxite and carbon, the reaction being expressed by the equation :—

$$21.\ Al_2O_3+3C+N_2=2AlN+3CO.$$

Bauxite is mixed with carbon and heated in the presence of nitrogen, combination taking place at about 1550° C. The reaction is hastened by the presence of certain catalytic agents, such as iron, silica, nickel, manganese, titanium oxide, &c. Of these iron and silica are the most active. The reaction is also facilitated by the presence of small quantities of acid gases such as hydrogen chloride and sulphur dioxide. Bauxite can be converted into aluminium nitride at a somewhat lower temperature than pure alumina, owing to the catalytic effect of its impurities. Below 1800° C. the velocity of the reaction is slow, but from 1800° C. to 1850° C. the absorption of nitrogen is very energetic, and in five minutes the alumina is completely converted into nearly chemically pure nitride. Smaller yields are obtained at higher temperatures, and above 2000° C. the formation of nitride practically ceases, owing to decomposition. Recently, Serpek claims to have reduced the time of reaction to a fraction of a second by suitable control of the reaction mixture and the nitrogen supply.

The apparatus employed by Serpek for the manufacture of aluminium nitride is shown diagrammatically in Fig. 13. It consists of two superposed rotating cylindrical kilns, slightly inclined to one another and rotating in opposite directions. Each of these kilns is 10 metres long. In the upper one, A, the powdered bauxite is introduced, which in its descent is calcined and heated to a temperature of 1400° C. by the passage of hot gases over it. On leaving the lower end of the kiln the calcined bauxite falls into the hopper, C, in the vertical chamber, B, where it is mixed with the proper amount of carbon (coal) introduced at D. The mixture then enters the upper end of the nitriding kiln, G, through the openings, E, and in its descent passes through the electrically heated region, F. Here the mixture is heated to the reaction temperature 1800° C.—1900° C. The kiln, G, is lined with compressed aluminium nitride. The electric resistance furnace, F, is detachable. The electric resistance consists of compressed carbon discs. These are arranged in eight columns each 1·2 metres long, which cross the furnace diametrically and which are connected in series. The resistances are fed by a direct current of 10,000 ampères at 230 volts. Producer gas (about 30 per cent $CO+70$ per cent N_2), which is formed in the generator, K, enters the lower end of G at a temperature of about 400° C. It passes through the kiln in the direction contrary to that of the descending charge, and in the electrically heated region, F, the nitrogen reacts with the alumina-carbon mixture in accordance with the equation (21). The producer gas, now enriched by the very hot carbon monoxide formed by the reaction, issues from the upper end of the kiln into the vertical chamber, B, preheating the descending charge as it moves along. At *a*, *b*, *c*, and *d* it meets with a blast of air which causes the carbon monoxide to burn to carbon dioxide, and the heat produced is employed to calcine and preheat the bauxite in the upper kiln. The nitride formed in the electrically heated region, F, is collected in the air-tight chamber, H. It contains about 26 per cent nitrogen.

Formation of Ammonia from Aluminium Nitride.

When aluminium nitride is treated with dilute aqueous alkali ammonia is produced, the reaction being expressed by the equation :—

$$22.\ AlN+3H_2O=Al(OH)_3+NH_3.$$

The decomposition takes place readily when the nitride is heated with the dilute alkali in an autoclave, with constant agitation, for from two to two and one-half hours under a pressure of two atmospheres, the ammonia being drawn off from time to time. The molecular ratio of sodium hydroxide to aluminium nitride is 1 : 1·5

In addition to ammonia a very pure alumina (free from silica and iron) is obtained even from the decomposition of an exceedingly impure nitride made from a low-grade bauxite. While this alumina is not particularly suitable to use over again for the production of more nitride, as owing to the absence of impurities it would require a much higher temperature than is required with bauxite, it is very suitable for the production of metallic alluminium.

Energy Requirements and Yields.

In the Serpek process there are required, in addition to the heat from coal and producer gas, about 12 kilowatt hours of electrical energy for each kilogrm. of nitrogen fixed. With a consumption of one kilowatt year 500 kilogrms. of nitrogen may be fixed and two tons of by-product alumina produced.

V. Absorption of Nitrogen as Cyanides.

Although it has long been known that cyanide can be formed by heating a mixture of carbon and alkali carbonate in an atmosphere of nitrogen, the development of this reaction for the fixation of atmospheric nitrogen on a commercial scale is due to the work of Bucher, carried out in the United States since the beginning of the war. Although the Bucher process is now working successfully in several small installations the mechanical difficulties of production on a large scale have still to be solved.

In this process a mixture of soda-ash and ground coke, or carbon in any form, is heated in contact with finely-divided iron in small retorts to a temperature of from 900—950° C. Nitrogen or air is passed through the heated mass, the nitrogen slowly reacting to form sodium cyanide, in accordance with the equation :—

$$23.\ Na_2CO_3+4C+N_2=2NaCN+3CO_2-138{,}500\ \text{cal.}$$

The part played by the iron in the reaction is that of a catalyst. The sodium cyanide may either be obtained by distillation of the reaction product, or by lixiviation with hot water.

The sodium cyanide formed in the reaction can be converted readily with air and steam into ammonia as follows : —The cyanide is maintained just above its melting-point and a current of air passed through the molten mass. It burns to sodium cyanate according to the approximate equation :—

$$24.\ NaCN+\text{air}=NaCNO+2N_2.$$

The nitrogen thus formed may be conducted into the cyanide furnaces. The sodium cyanate is then heated with water, which converts it into ammonia long before the boiling-point is reached, in accordance with the equation :—

$$25.\ NaCNO+H_2O=NaHCO_3+NH_3.$$

The sodium bicarbonate may be used over again in the production of more cyanide.

Unlike other processes for the fixation of atmospheric nitrogen in this cyanising process no power factor of any considerable magnitude is involved. Of the raw materials the iron is always recoverable. This also applies to the sodium carbonate, if the final product is ammonia. The raw materials actually expended are, therefore, coke and nitrogen for the cyanising reaction, steam for the production of ammonia, and coal for furnishing the heat. Bucher has suggested the possibility of employing for

fuel the three moles of carbon monoxide formed in the reaction expressed by equation (23), which when burned would yield:—

$$26.\ 3CO+O_2=3CO_2+200,000 \text{ cal.}$$

The process at the present time involves a large investment and high labour and repair charges, but, as previously mentioned, if the mechanical difficulties are successfully overcome, it appears that nitrogen may be fixed in the form of cyanide more cheaply than by any of the processes already described.

(To be continued).

NOTE ON CERTAIN EFFLUENT WATERS FROM TIN DRESSING FLOORS IN CORNWALL.*

By Prof. J. C. PHILIP, M.A., D.Sc., Ph.D.

The samples of effluent water sent me for examination were from three sources—(A) Red River water below Dolcoath but above South Crofty; (B) Red River water just below East Pool; (C) Effluent, from Giew Mill.

Samples A and B came into my hands about five days after being taken. In that time they had deposited much sediment, 16—17 grms. per Winchester quart, say 2·5 litres, in the case of A, and 40—50 grms. per Winchester quart in the case of B. The supernatant water was absolutely clear. It was still possible, however, that this clear water might contain tin in the colloidal condition, and I accordingly made a careful comparison of this water with a colloidal solution of stannic acid prepared for the purpose.

A quantity of 300 cc. solution containing 0·03—0·04 grm. SnO_2 as colloidal stannic acid was acidified with hydrochloric acid and reduced by boiling with Swedish iron. The volume of a standard iodine solution subsequently required for oxidation was 4·4 cc. On the other hand, in exactly parallel experiments with 300 cc. of the clear supernatant liquid from A and B, carried out under precisely the same conditions, the volume of the standard iodine solution required was the same as that taken in a blank, viz., 0·1—0·3 cc.

These experiments, as well as observations on the absence of any effect of a strong electric field on the clear water from A and B, prove, in my opinion, that these waters do not contain tin in any form, colloidal or otherwise.

Sample C, when it reached me, had deposited much sediment—80—90 grms. per Winchester quart—and the supernatant water was reddish in colour and very turbid. Sedimentation was not complete even after the lapse of weeks. The suspended matter, examined in a strong electric field, was found to move towards the anode, so that the charge on these particles must be a negative one. This conclusion was confirmed by observing the relative influence of sodium sulphate, magnesium sulphate, and ammonia alum in promoting the sedimentation of the turbid water. The effectiveness of these sulphates increases in a notable degree from sodium to aluminium, and this marked superiority of the iron with a triple positive charge over those with a double or single positive charge supports the view that the suspended particles carry a negative charge. The quantity of alum required to bring about sedimentation is exceedingly small. The addition of 5 mgrms. of ammonia alum to 100 cc. of the turbid Giew Mill water led to complete flocculation and sedimentation within a few minutes.

Another specimen of the Giew Mill water, forwarded to me at a later date, appeared to settle more rapidly than did the first sample. About a month after the arrival of the second sample, 300 cc. of the still slightly turbid liquid were drawn off, acidified with hydrochloric acid, and boiled with Swedish iron. The amount of iodine solution subsequently required for oxidation was, however, practically the same as that needed in a blank experiment carried out under the same conditions.

Whilst it is not possible to differentiate in the early stages between the suspended matter and possible colloidal tin in the Giew Mill water, the tin is certainly not present in any reasonably permanent colloidal condition. If, in the early stages after leaving the dressing floors, the tin is temporarily in colloidal solution, this is practically the same as if it were present as a fine mechanical suspension. It would scarcely be possible to differentiate the two conditions.

* From *Bulletin of the Institution of Mining and Metallurgy*, August, 1919.

ILEX VOMITORIA AS A NATIVE SOURCE OF CAFFEINE.

By FREDERICK B. POWER and VICTOR K. CHESNUT.

In connection with the war activities of the National Research Council a question was submitted to the Chemistry Committee, of which at the time Lieut.-Col. Bogert was Chairman, respecting "the possibility of increasing the present production of caffeine, and the utilisation of other sources than tea." This problem was referred to one of the present authors, as Chairman of the Sub-Committee on Pharmaceutical Chemistry, for investigation.

The occurrence of caffeine in several distinct families of plants is quite remarkable, and it is also an interesting fact that it is chiefly the plants containing caffeine which have been employed in different countries for beverage purposes. In this connection it may furthermore be noted that the occurrence of caffeine appears to be restricted to certain species of a genus, for it has been stated that a number of species of *Coffea* do not contain it, and the same conditions have previously been observed, and now confirmed by us, with regard to plants belonging to the genus *Ilex*.

The chief source of caffeine, as is well known, is tea, and for its commercial production the inferior qualities, damaged material, and the dust obtained by sifting the leaves are generally employed. Although the so-called *Maté*, *Yerba Maté*, or Paraguay Tea, which is said to be yielded by several South American species of *Ilex*, but is generally referred to *Ilex paraguariensis*, St. Hilaire, contains a notable proportion of caffeine, it appears not to be utilised for the preparation of this substance. Nevertheless, according to a report from William C. Downs (*The Official Bulletin*, Washington, D.C., September 21, 1917, p. 5), commercial attaché at Rio de Janeiro, the amounts of *Yerba Maté* exported from Brazil during the first six months of the years 1016 and 1917, presumably for beverage purposes, were respectively 40,441 and 24,483 metric tons.

The occurrence of caffeine in the above mentioned species of *Ilex* suggested a more complete examination of the North American species than had hitherto been made (compare Wehmer, "Die Pflanzenstoffe," 1911, p. 456). In an article published by Henry M. Smith (*Sci. Am.*, March 30, 1872, and *Am. Journ. Pharm.*, 1872, xliv., 216), under the title of "Yaupon," the author states that this is "the name given by the Indians to the leaves of *Ilex cassine*, a plant indigenous to the Southern States, but found only along the coast from Florida to North Carolina." (According to recent information from Dr. R. M. Harper, the *Ilex vomitoria* is still known locally by different common names. It is commonly called "yupon" in Virginia and north-eastern North Carolina, and also in Florida and Texas, "yopon" in southern North Carolina, and "cassena" in South Carolina). "Mixed with the leaves of other species of the same plant, *Ilex vomitoria* and *Ilex dahoon*, it formed 'Cassena,' the basis of their famous 'black drink,' which was used by the red men as a

medicine, and as a state drink at some of their religious festivals." The author has also noted that "Yaupon is largely used in the south as a substitute for tea, coffee, and other stimulants, and is reputed to be very beneficial to inebriates who wish to cure themselves of the love of liquor." The constituents of "Yaupon," as recorded by Smith, such as volatile oil, resin, chlorophyll, gum, &c., render it evident that he employed for his investigation the unaltered leaves of the plant, and not the parched mixture of leaves and twigs to which the name "Yaupon" is also applied. Smith (*loc. cit.*) appears to have been the first to have noted the presence of caffeine in a North American species of *Ilex*, and gives the amount found as 0·122 per cent, which was observed to agree very closely with the proportion of 0·13 per cent found by Stenhouse in Paraguay tea. These very low percentages are doubtless to be attributed to imperfect methods of assay, since both kinds of material are now known to contain very much larger amounts of caffeine.

An important contribution to the subject under consideration is a publication by Dr. E. M. Hale entitled "*Ilex cassine* (see Note), the aboriginal North American tea; its history, distribution, and use among the native North American Indians" (U.S. Dept. Agr. Div. of Bot., *Bull.* 14, 1891). After referring to the use of the shrub by our native Indians and by the white people who once adopted it as a beverage, Dr. Hale remarks that "the reason for its disuse is hard to discover, for, in common with the tea and maté, it contains caffeine or a similar alkaloid. The object of this paper is to examine its history, to suggest its restoration to a place among the stimulant beverages, and to inquire into its possible economic value."

(Note.—Much confusion appears to exist with regard to the botanical names of certain species of *Ilex*. The *Ilex cassine* of Walter (but not of Linné) is the *Ilex vomitoria*, Aiton, and, as we have shown, it is only the species to which the latter name is now assigned which contains caffeine).

In a paper of much interest entitled "Narcotic Plants and Stimulants of the Ancient Americans," by W. E. Safford, of the Bureau of Plant Industry, U.S. Deparment of Agriculture, the "black drink" of Florida and the Carolinas has been considered (*Ann. Rep. Smithsonian Inst.*, 1916, p. 416). This is accompanied by an excellent illustration of *Ilex vomitoria*, and a reproduction of an old print, dated 1564, showing the black drink ceremony as performed in northern Florida.

In the above mentioned publication by Hale reference is made to some analyses by F. P. Venable of leaves designated as *Ilex cassine*, which had been recorded at an earlier date (Elisha Mitchell, *Sci. Soc.*, 1883, lxxxiv., [II.], 85; *Journ. Am. Chem. Soc.*, 1885, vii., 100). It was stated by Venable that leaves procured from Newbern, N.C., during the winter of 1883 yielded 0·32 per cent of caffeine, and that in the following May leaves obtained from the neighbourhood of Wilmington, N.C., were found to contain 0·27 per cent of caffeine.

Experimental.

Through the kind co-operation of Mr. Frederick V. Coville, botanist of the U.S. Department of Agriculture, Bureau of Plant Industry, we have been able to obtain a considerable number of representative samples of *Ilex vomitoria* for the purpose of chemical examination. This material was personally collected during the summer of 1918 by Dr. Roland M. Harper, who, through his previous botanical explorations in the South-Eastern States, was thoroughly familiar with the plant and the localities where it is most abundant. In the present instance the leaves were collected at various places in the coastal region, extending from Virginia to Texas, and from plants growing under different conditions of soil and climate. In all cases the leaves, stripped from the branches, were sent to us immediately after gathering, and were then dried in the air without artificial heat. The following enumeration of the different samples of leaves will indicate the localities from which they were obtained, and reference will be made to these numbers in stating their caffeine content.

1. Cedar Island, in Back Bay, Princess Anne Co., Va.; (*a*) from plants growing wild; (*b*) from cultivated plants in garden at Munden, Va. 2. Smith's Island, at mouth of Cape Fear River, N.C. 3. About three miles north of Georgetown, S.C. 4. Tybee Island, Ga. 5. Coquina hammock, Anastasia Island, Fla. 6. Sandy hammock, in central part of Wakulla Co., Fla. 7. St. George's Island Franklin Co., Fla. 8. Hammocks near Kountze, Hardin Co., Tex.; (*a*) young leaves; (*b*) older leaves. 9. Rocky banks of Bee Creek, Travis Co., Tex. 10. Bottoms of Brazos River, Brazoria Co., Tex.

In all of the above mentioned samples the amount of caffeine was quantitatively determined according to the method which has been fully described by us in a preceding paper. It may be noted, however, that in the present investigation, for the purpose of control, quantitative determinations of the caffeine were also made with 50 grms. of each of the samples, although ordinarily the use of more than 10 grms. of material is neither necessary nor advisable. The same method of procedure as that already described (*loc. cit.*) was followed, with the exception that for 50 grms. of the leaves 25 grms. of magnesium oxide was employed, and about 1 litre of aqueous filtrate was obtained. This was heated with 50 cc. of a 10 per cent solution of sulphuric acid, and, after filtration, the liquid was extracted with 20 successive portions of chloroform of 25 cc. each, the united chloroform extracts being finally shaken with 25 cc. of a 1 per cent solution of potassium hydroxide. The results of the two series of determinations will be seen to be in close agreement, thus indicating the accuracy of the method. This, moreover, has been confirmed by numerous assays of other vegetable material of different character, which are recorded in the preceding publication.

Amounts of Caffeine found in Different Samples of Leaves.

Number of sample.	Percentage of caffeine. 10 grms. assay.	50 grms. assay.
1 (*a*)	1·29 ; 1·30	1·25
1 (*b*)	1·25	1·21
2	0 57	0·54
3	0 95	0·92
4	0·39	0·38
5	0 99 ; 0·99	0·95
6	0 80	0·78
7	0·40	0·40
8 (*a*)	0·95	0 89
8 (*b*)	0·32 ; 0·36 ; 0·36	0·35
9	1·63 ; 1·67	1·65
10	0·84 ; 0·88	0·79

In addition to the above mentioned collection of leaves of *Ilex vomitoria* we were able to examine two samples of leaves from cultivated plants. These were procured through the kind co-operation of Dr. David Fairchild, of the Bureau of Plant Industry, and they were both definitely identified by Mr. W. E. Safford as the leaves of *Ilex vomitoria*, Aiton. One of these samples, received early in September, was obtained from Glen St. Mary, Fla. Two 10 grm. assays yielded 1·38 and 1·42 per cent respectively of caffeine, and in a 50 grm. assay 1·40 per cent of caffeine was obtained. The other sample of cultivated leaves was received from a nursery at Augusta, Ga., and had been collected in the month of October. It was surprising to find that these leaves were almost completely devoid of caffeine. By the described method of assay 10 grms. of the leaves yielded 0·17 per cent of a product which was only partly crystalline. When this

was treated with water, and the aqueous liquid evaporated, a colour reaction was obtained by the murexide test which was comparable with that produced by 0·1 mgrm. of caffeine. In view of this anomalous result a sample of leaves was collected in the month of April from the same shrub and again examined. A 10 grm. assay of the leaves yielded but 0·16 per cent of a partly crystalline product, which, by comparative colour tests, could not have contained more than about 0·5 mgrm. of pure caffeine. Although the amount of caffeine in the designated sample of cultivated leaves was so extremely small that it might easily have been overlooked, the fact of its presence afforded a satisfactory confirmation of the botanical identification of the leaves as those of *Ilex vomitoria*.

It was deemed desirable, by nitrogen determinations, to ascertain the degree of purity of the caffeine obtained from the leaves of *Ilex vomitoria* although such determinations by the Kjeldahl method had previously been made with the products of assay from a considerable variety of material, and with fairly uniform results.

(*a*) Caffeine from a 50 grm. assay of leaves from wild plants, collected near Georgetown, S.C. (No. 3).

Subs., 0·1 grm. ammonia equivalent to 19·1 cc. 0·1 N HCl, corresponding to 0·0268 N or 0·0928 caffeine. Yield of caffeine—by weight, 0·92 per cent; calc. from N, 0·85 per cent.

(*b*) Caffeine from a 50 grm. assay of leaves from cultivated plants, obtained from Glen St. Mary, Fla.

Subs., 0·1 grm. gave ammonia equivalent to 19·4 cc. 0·1 N HCl, corresponding to 0·0272 N or 0·0942 caffeine. Yield of caffeine—by weight, 1·40 per cent; calc. from N, 1·32 per cent.

It has already been noted that for the preparation of the so-called "black drink," as in later times for making "yaupon tea," the leaves of *Ilex vomitoria* were first parched before being infused or boiled with water. In order to ascertain whether the caffeine was destroyed by this treatment, a quantity of such material was prepared for us in the accustomed manner by a native of Virginia under the personal observation of Dr. R. M. Harper. The plants used for this purpose were those grown in a garden at Munden, Va., the leaves of which had previously been assayed for caffeine, and are designated in the tabular list as 1 (*b*). As the material consisted of a parched mixture of broken leaves and stems, which had a very unpleasant smoky odour, it was necessary to grind the whole of it in order to obtain a uniform sample for the determination of the caffeine. Fifty grms. of the resulting black powder was treated according to the described method of assay, when the yield of slightly yellowish caffeine was 0·5217 grm. or 1·04 per cent. Inasmuch as the material examined contained a considerable proportion of the woody stems of the plant, together with the leaves, both of which were in a more or less charred condition, the amount of caffeine found was quite unexpected. In comparing the caffeine content of this material with that of the corresponding sample of leaves (1·21 per cent), it should, however, be considered that it had been very much more highly dried.

The result obtained by the examination of the so-called "yaupon" renders it evident that the high temperature to which the material had been exposed had not caused the destruction of the caffeine, and that a beverage prepared from it would possess decided stimulating properties.

In the course of the present work it was deemed important to examine the leaves of all the available American species of *Ilex* for the presence of caffeine, although previous investigators had shown this to be absent in several species, including the European holly, *Ilex aquifolium*, Linné (compare Wehmer, "Die Pflanzenstoffe," 1911, p. 456). Samples of leaves of the following species of *Ilex* were therefore obtained, and our thanks are due to Mr. W. E. Safford, of the Bureau of Plant Industry, for their careful botanical identification.

Ilex cassine, Linné, from Little River, Fla.
Ilex glabra, Gray, from vicinity of Orlando, Fla.
Ilex laevigata, Gray, from East Hyattsville Swamp, Md.
Ilez myrtifolia, Walter, from plants cultivated at Glen St. Mary, Fla.
Ilex opaca, Aiton, from different localities near Orlando, Fla., and also from vicinity of Hyattsville, Md.

In none of the above mentioned species of *Ilex* could any trace of caffeine be detected.

Summary.

The results of this investigation have demonstrated that an abundant source of caffeine is available in one of our native plants, namely, *Ilex vomitoria*, Aiton. Although considerable differences in the caffeine content of the leaves of the plant have been found to exist these are doubtless attributable to varying conditions of soil and climate. It would therefore appear that by the cultivation of the shrub under the most favourable conditions the supply of material for the production of caffeine could be increased to any desired extent.

So far as has at present been ascertained no other North American species of *Ilex* than that above mentioned contains caffeine, and this substance is also not contained in the leaves of the European holly, *Ilex aquifolium*, Linné.

In conclusion, the authors desire to express their indebtedness to Mr. Frederick V. Coville, of the Bureau of Plant Industry, for his generous co-operation in securing most of the material for this investigation, and our thanks are also due to Dr. Ronald M. Harper, who had so carefully collected the required samples of leaves of *Ilex vomitoria* over a wide range of territory.—*Journal of the American Chemical Society*, xli., No. 8.

SOME OPTICAL AND PHOTO-ELECTRICAL PROPERTIES OF MOLYBDENITE.*

By W. W. COBLENTZ and H. KAHLER.

This paper gives data on the transmissivity and the reflectivity of molybdenite; also data upon its change in electrical conductivity, when exposed to thermal radiations of wave-lengths extending from the ultra-violet into the extreme infra-red.

The effect of temperature, humidity, intensity of the exciting light, &c., upon the photo-electrical sensitivity of molybdenite was investigated.

It was found that:—

1. Samples of molybdenite, obtained from various localities, differ greatly in sensitivity.

2. There are maxima of sensitivity in the region of 0·73μ, 0·85μ, 1·02μ, and 1·8μ.

3. There is no simple law governing the variation in the photo-electric response with variation in intensity of the radiation stimulus.

4. The increase in photo-electric current with increase in intensity of the incident radiation is greatest for infra-red rays. It is greatest for low intensities of the exciting light, and it is greatest on the long wave-length side of the maximum.

5. The photo-electric sensitivity increases with decrease in temperature. At 70° C. the bands at 1·02μ and 1·8μ have practically disappeared. On the other hand, at liquid air temperatures, the greatest change in electrical conductivity is produced by radiations of wave-lengths between 0·8μ and 0·9μ.

Unlike selenium, molybdenite appears unique in being photo electrically sensitive to infra-red rays, extending to about 3μ.

* U.S. Bureau of Standards, Scientific Paper No. 338. From the *Journal of the Franklin Institute*, August, 1919.

VACUUM ARC SPECTRA OF VARIOUS ELEMENTS IN THE EXTREME ULTRA-VIOLET.*

By Prof. J. C. McLENNAN, F.R.S.; D. S. AINSLIE, M.A.; and D. S. FULLER, M.A., University of Toronto.

(Continued from p. 103).

9. *Iron.*—For the vacuum arc spectrum of iron the electrodes were made of the material technically known as mild steel. It was very difficult to secure a strong arc, and with currents as high as 16 amperes only an intermittent arc of moderate intensity was secured. In the resultant spectrum several lines belonging to carbon showed up prominently. Omitting these from our list the measurements of the lines apparently due to iron itself are given in Table X. This list does not include wave-lengths of lines which showed up on one or two plates, but with such a small intensity that accurate measurements for them were not possible. As far as is known this is the first time the vacuum arc spectrum of iron has been measured. Eder and Valenta, Bloch, and Takamine and Nitta give measurements in this region for the iron spark spectrum, and their lists contain a large number of wave-lengths. The spark spectrum, as a whole, differs considerably from the vacuum arc spectrum as obtained in our work.

TABLE X.—*Iron.*

Intensity.	The Authors. λ (A).	1/λ.
5	2394·5	41,762
5	2380·2	42,013
4	2360·0	42,373
4	2346·0	42,626
2	2097·5	47,666
4	2078 8	48,105
3	2061·5	48,508
2	1926·0	51,921
4	1913·8	52,252
3	1894·3	52,790

TABLE XI.—*Nickel.*

Intensity.	The Authors. λ (A).	1/λ.	Bloch. λ (A).
1	2005·0	49,875	2004·35
6	1991·0	50,226	{ 1992·82 1989·56
2	1982·0	50,454	1981·89
4	1964·8	50,895	1964·63
2	1902·3	52,568	1902·70
4	1859·2	53·786	1857·99
6	1854·5	53,923	1853·41
5	1849·7	54,063	
6	1846·7	54,151	
6	1829·4	54,663	
4	1822·5	54,870	
4	1818·7	54,984	
1	1806·7	55,350	
4	1794·3	55,732	
4	1790·5	55,850	
4	1787·5	55·944	
2	1781·7	56,216	
9	1767·8	56,568	
6	1763·2	56,715	
1	1758·7	56,860	
6	1750·8	57,117	
6	1746·0	57,274	
5	1740·2	57,465	
5	1737·3	57,561	
2	1732·3	57,727	
3	1729·4	57,824	
3	1722·2	58,063	
5	1720·0	58,140	
6	1714·8	58,282	
6	1709·5	58,497	
3	1707·3	58,572	
2	1701·3	58,779	
2	1698·3	58,882	
8	1692·5	59,084	
4	1687·9	59,245	
2	1661·8	60,176	
2	1656·5	60,368	
6	1653·2	60,489	
2	1650·1	60,569	

10. *Nickel.*—The arc spectrum of nickel was obtained with the arc lamp, using circular rods of the metal as electrodes. With a current of 7 amperes on closed circuit, an intense intermittent arc was secured. The measurements for the wave-lengths of this spectrum below λ 2000 A are given in Table XI. The spectrum is remarkable for the large number of sharply defined lines which it included. Eder and Valenta and Bloch (*Journ. de Phys.*, 1914, Ser. 5, p. 631), have measured the spark spectrum of nickel, and give lists which contain a great number of wave-lengths not observed in our work. This may be largely due to the fact that they used a spark as a source of light while we used a vacuum arc. In all our plates lines were observed at λ 2195·2 A, λ 2187·5 A, and λ 2218·3 A. Below λ 2000 A many new lines were observed and measured. For the work with nickel it was not possible to secure chemically pure metal. The samples used for electrodes were of the ordinary commercial quality, and as a consequence some of the fainter lines recorded in the Table may have been due to impurities.

(To be continued).

* From the *Proceedings of the* [Ro]*yal Society*, A, xcv., 316.

PICRIC ACID MANUFACTURE.

A PROCESS for the manufacture of picric acid which is stated to secure a considerably increased yield and a reduction in labour, together with the prevention of liberation of N_2O_4 gas, is described in a recent patent (British Dyes, Limited, J. Turner and L. G. Badier; No. 126,368). By the improved process it is also claimed that waste acid of high concentration is obtained, which can be directly used in the manufacture of nitric or hydrochloric acid.

It has been proposed to obtain picric acid by the transformation of phenoltrisulphonic acid by nitrate of soda, and it is known that it is usual to nitrate phenol (in the manufacture of picric acid) by dissolving one part of phenol in three, four, or five parts of ordinary H_2SO_4 (65°/66° Be.) The addition is made while cold, and the phenol combines with the H_2SO_4 to form a sulphonated phenol which is principally the compound para-sulphophenol (1—4) accompanied by a quantity more or less of disulphonated products (1—2—4) according to the raising of the temperature at which the sulphonation has taken place, the temperature rising above 100° C. When the sulphophenol has been cooled there is added a certain quantity of water variable in every manufacture, and when the mixture has cooled to ordinary temperature, the quantity of nitric acid, calculated to be necessary for the nitration, is added. During this nitration considerable quantites of N_2O_4 are liberated which is part of the nitric acid used, and at the same time a cause of bad yield of picric acid, the formation of N_2O_4 being the indication of a destruction of the phenol molecule, of which the final termination is carbonic and oxalic acid, the latter of which is always recoverable in larger or smaller quantities in the waste acids.

It is also known that the para-sulphophenol obtained from sulphanilic acid can be entirely nitrated in solutions of water when even very dilute and with a theoretical amount of HNO_3. This nitration takes place without emission of N_2O_4 gas, and the research for oxalic acid in the mother-liquors gives a negative result which must be attributed to the purity of para-sulphophenol (1—4), and it is thus that the radicle SO_2H in para position permits

the entrance of the three groups of NO_2 in the position 2—4—6 in the phenol molecule. The trisulphonated compound of phenol will answer the same purpose.

It may be noted that the trisulphonated product does not easily fasten NO_2 in concentrated H_2SO_4; indeed on the addition of the nitric acid the thermometer indicates a strong rise in the temperature on the addition of the first molecule of HNO_3; on the addition of the second molecule the thermometer indicates a slight rise, and rests stationary on the additional of the third molecule. Even the heating up to 130° C. or 140° C. produces little effect, but if water or steam is added the replacement of the SO_3H group by that of the NO_3 immediately takes place.

The patentees have found that water or steam put into the mass with suitable agitation favours the departure of the SO_3H groups in the phenol molecule to fasten to it the NO_2 group. As an example, in an enamelled vessel of sufficient capacity (with agitator) they put H_2SO_4 at 95 per cent 840 lbs., and oleum at 70 per cent SO_3 160 lbs. This mixture is brought to a temperature of about 60° C. and there is added, with agitation, 188 lbs. of melted phenol at the temperature of about 60° C. The mixture warms up to 130—140° C., and is then allowed to cool naturally, with agitation. When the temperature has arrived at 20° C. they add slowly a nitric mixture, at the same time cooling exteriorly, said mixture being composed of nitric acid at 86 per cent, 470 lbs., and sulphuric acid 66 Be., 470 lbs., so that the temperature rises to about 100° C. After making the addition, very little picric acid is noticed, but they then pass a stream of steam or water into the acid, and immediately the picric acid forms little by little in paste in the midst of the acid, and gradually as the temperature rises to 140° C. When the reaction is finished, the steam is shut off, and the reaction mass is cooled by circulating cold water exteriorly.

The picric acid forms in small crystals, flat and flaky. When the cooling has arrived at 20° C. it is filtered on asbestos cloth. The acid is extracted by vacuum, and the precipitate washed one or twice on the filter to remove the acid. The precipitate is now placed in a suitable vessel such as a large wooden tub with a wood agitator, and water is added until the tub is three quarters full, the water being heated up to 80—85° C. with a stream of steam. Cold air is now blown on to the mass, with agitation, and when the temperature arrives at 20° to 25° C. there is added 100 lbs. of HCl of 30 per cent to 33 per cent, and the whole is filtered on a wooden vacuum filter, free from all metal. The product is afterwards dried in a vacuum, then placed in a hydro extractor, and from thence carried to a hot room.

By the above process a chemical reaction is brought about which first produces para-nitrated disulphonic phenol and then transforms it into the trinitrated phenol. The steam can be considered in this reaction as a catalytic agent, its use being to assist in the replacement of the SO_3H groups by the NO_2 groups. The patentees do not confine themselves to exact proportions nor temperature specified, as they may be varied somewhat, as for instance, the phenol may be dissolved in the sulphuric acid and the oleum added.—*Chemical Engineering*, August, 1919.

RECENT DEVELOPMENTS IN THE CHEMICAL INDUSTRY IN ITALY.

BEFORE the war there were two electrolytic plants in Italy, those of Caffaro aad Bussi, both situated near Pescara in Brescia. When the war began a third plant was opened by the Government at Rumianca, Province of Novara.

The latest was established at Naples, and work was begun in March, 1918. It is known as the Elettro-chimica Pomilio. The company has been obliged to build its own plant, and almost to create its own machinery.

The main process in the Pomilio works is the decomposition by electrolysis of salt and the resolving of it into component parts, all of which are utilised. The result is the production of caustic soda, hydrogen, and chlorine (including chlorine derivatives).

According to a report by the United States Consul at Naples, the only raw material used is sodium chloride or salt, which is extracted from the mines in Poto Empedocle in Sicily, and is called salgemma. This product is purer than sea salt as regards sulphate content. It is brought in large lumps to Naples by sailing boats and taken in vehicles to the plant 650 ft. from the bay. It is then roughly crushed and dissolved in three concrete tanks, after which the water solution is brought up to saturation (24° to 25° Baumé). To purify its salt further the Elettrochimica Pomilio uses barium chloride, which precipitates the last traces of sulphate. The barium sulphate precipitated is sold as a by-product.

The works comprise electrical, evaporating, electrolytic, and chlorine compression installation and chlorine derivatives department.

The electrolytic department contains three electrolytic batteries of a diaphragm type of nearly 500 h.p. each. The salt is dissolved and fills a concrete reservoir, from which it is pumped up in a feeding reservoir, whence it is distributed through small glass tubes into the electrolytic cellules in contact with seven graphite anodes, through which the electric current passes. The saturated saline solution is kept in continuous circulation.

The chlorine gas released by the action of the electric current is conveyed through earthenware piping to sulphuric-acid towers, where it is dried by passing over a surface of liquid sulphuric acid. Chlorine is used as such in gas form or is reduced by combined cold and pressure to a liquid state, is transferred into alkaline hypochlorides, or is worked up in other forms of asphyxiating gas.

The residuum of diluted caustic soda is conveyed into large reservoirs, one iron and one concrete tank for each battery. These thanks are situated in a cellar underneath the electrolytical hold, where the caustic liquid flows by gravity. Both kinds were installed, as it was not known which would best resist the action of the caustic soda content.

The hydrogen is obtained in a very pure state and compressed in a special department into steel cylinders at 150 atmospheres. The cylinders are of tubes, tested to at least 300 atmospheres, and prepared into a process originally patented by Gebrüder Mannesmann, Falk, near Köln. The actual capacity is 75 litres (20 gallons) per cylinder. The very pure hydrogen may be used for airships.

There is an extensive use of rotary pumps at the plant. Electrical motors, pumps, and other appliances are all in duplicate, so as to eliminate any accidental stop.

The Pomilio plant is the most modern in Italy, and the first to be established in Southern Italy, which furnishes an excellent market for caustic soda and chlorine derivatives. It is expected that the improvements introduced by the company in the electrolytic manufacture and working up of caustic soda and chlorine will greatly contribute to the further development of this industry. The company also intend introducing liquid chlorine to substitute alkaline hypochlorites for bleaching purposes in paper and textile mills.—*Journal of the Royal Society of Arts*.

INTERNATIONAL INSTITUTE OF AGRICULTURE.

THE *Bulletin of Agricultural and Commercial Statistics* for the present month, as also for July, has not been published on account of the strike of printers which began in Rome over a month ago. While the regular publication will be resumed at the end of the strike, meanwhile the following *résumé* will show specially the results of the cereal crop harvests which are already finished or in full progress in Northern Hemisphere countries.

Wheat.—Table I. shows the figures for the yield of the current year compared with those of 1918 and with the average of the previous five years (1913—1917).

For the group of countries indicated this year's yield therefore turns out 2·7 per cent below last year's, and 2·2 per cent above the average for the five years 1913—1917 in these countries.

Rye.—For this cereal the yield up to the present is given for Italy, Canada, and the United States. In Italy it is estimated at one million quintals or 75·2 per cent of last year's, and 79·1 per cent of the average for 1913—1917. For Canada the estimate is 2·2 million quintals, or 100·8 per cent of last year's crop, and 318·9 per cent of the average for the preceding five years. For the United States the estimate is 21·5 million quintals or 93·8 per cent of last year's crop and 169·2 per cent of the average yield for the five years 1913—1917.

Barley.—Table II. figures show this year's crop compared with that of 1918 and w'th the average for the five previous years.

This year an appreciable decrease appears in the yield as compared with 1918 for all these countries except Scotland and Japan. Compared with the five year average the yield this year is slightly in excess for the United States (2·4 per cent), and much more so for Canada (39·1 per cent), the latter increase being due to the greater area under crop in 1919.

Oats.—Table III. is the data for those countries which have up to the present supplied figures of yield for the current year.

Table I.

Country.	Yield in 1919. Millions of quintals.	Percentage of 1919 yield compared with— 1918.	Average for 1913—1917.
Spain	37·7	102·0	104·4
Italy	42·0	84·2	88·8
Canada	67·6	131·4	94·4
United States	255·8	102·5	118·9
British India	75·3	72·8	76·2
Japan	8·1	96·1	111·9
Tunis	1·8	78·3	105·1
Total and index figures	488·3	97·3	102·2

Table II.

Scotland	1·3	106·0	95·5
Italy	1·7	80·6	84·4
Canada	14·7	87·5	139·1
United States	44·4	79·6	102·4
Japan	19·9	114·6	95·0
Algeria	6·9	—	87·7
Tunis	1·2	60·0	76·7

Table III.

Scotland	6·8	75·0	100·9
Italy	4·5	68·4	96·2
Canada	67·9	103·3	107·2
United States	183·8	82·3	95·1
Japan	1·4	145·3	163·5
Algeria	1·4	—	69·2

The notable decrease in the yield for the current year as compared with 1918, and with the average for the five preceding years for Scotland, Italy, and still more for the United States, which is by far the most important producing country for this crop, cannot be counteracted by the larger estimates that are now being made of the Canadian crop.

Maize.—For this crop the figures of yield are known only for countries in North America. In Canada the yield is estimated at 2·6 million quintals or 73·5 per cent of the 1918 yield, and 88·4 per cent of the average for the five years 1913—1917. The United States crop is estimated at 708·2 million quintals, or 107·9 per cent of that in 1918, and 101·4 per cent of the average for the preceding five years.

Rice.—Only the United States figures are available for this crop, which is estimated at 8·9 million quintals of rough rice, or 107·4 per cent of the 1918 figure and 141·0 per cent of the average of the five years 1913—1917.

Linseed.—In almost all the more important countries for the production of linseed a great decrease appears this year as compared with the yields of former years. The United States crop is estimated at 2·6 million quintals, or 69·6 per cent and 71·9 per cent of the 1918 figure and the average for the previous five years respectively.

Still greater is the decrease in the yield for India, where the estimate stands at 2·3 million quintals, or 44·5 per cent and 48·8 per cent of the 1918 figure and the average for the five years 1913—1917 respectively. In Canada the yield of linseed is estimated at 2·1 million quintals or 135·0 per cent of the 1918 crop and 82·5 per cent of the five-year average.

In the case of the countries and the cereals for which official figures for the current year's crop are not yet available, the following reports are issued:—The condition of the cereal crops at the beginning of July was not altogether satisfactory in Great Britain and Ireland on account of cold winds which damaged the crops. At the beginning of August the condition was better for Ireland, but in England and Scotland the rains during July were not sufficient to bring about much improvement. In Italy, where the drought and variable temperature during June caused unequal ripening, the weather remained dry also during July, and favoured harvesting operations for wheat and other similar cereals, but badly deteriorated the maize crop in some provinces. In the Netherlands rains during July were beneficial to the cereal crops, and in Sweden at the beginning of August the condition of the crops was reported to be satisfactory.

The potato crops at August 1 were in good condition in Sweden and Ireland, where a good yield is expected, but in England, Scotland, and Italy the plants suffered from want of rain. In the United States the yield is estimated at 106·4 million quintals of potatoes, or 97·7 per cent of the 1918 figure and 106·8 per cent of the average for 1913—1917, while in Canada the yield is estimated at 27·4 million quintals, or 96·3 per cent and 135·9 per cent of last year's crop and the average of the preceding five years respectively.

Sugar beets were in good condition in Sweden but much below normal in the United States, where, however, in consequence of an increased area under the crop, the yield of this year, which is estimated at 63·1 million quintals, is 18·2 per cent greater than that of last year and 17 per cent greater than the five-year average (1913—1917).

The cotton crop at August 1, 1919, was in a condition below normal, while at the same time in the United States a fair decrease was reported in the area under the crop. The yield, which is estimated at 23·8 million quintals, amounts to 91·4 per cent of the 1918 figure and 83·4 per cent of the average for the preceding five years.

For vines the season up to the present has been favourable in Italy, but in some provinces attacks of mildew are reported.

For tobacco the yield of the United States is estimated at 6·1 million quintals, or 99·6 per cent and 122·3 per cent of last year's crop and of the average of the preceding five years respectively.

The agricultural section of the *Bulletin* concludes with a table on seri-culture in 1919 which shows the production of cocoons in Italy to be estimated at 25 million kilogrms., much below the production in 1918 (84·7 per cent) and still further below the average of the five years 1913—1917 (69·9 per cent). In Japan the production of spring and summer cocoons is estimated at 147·7 million kilogrms. this year, which is below the corresponding production in 1918 (95·7 per cent), but higher than the average for the five years (115·2 per cent).

Rome, August 23, 1919.

BOARD OF TRADE ANNOUNCEMENTS.

IMPORT RESTRICTIONS.

WITH reference to the Prime Minister's statement in Parliament on Monday, August 18, on the subject of Trade Policy the Board of Trade make the following announcement as to the steps which are proposed in connection with imports of goods from abroad.

Legislation will be introduced when Parliament re-assembles in the autumn:—

(a) For the protection of goods manufactured in Great Britain and Ireland against Dumping, by taking power to prevent the sale in this country of similar goods beneath their price in the country of origin.

(b) To enable the Board of Trade to check any flood of imports (for instance from Germany) that might arise from a collapse of exchange so disproportionate to cost of production in the country of origin as to enable sales to take place in this country at prices altogether below costs of production here.

(c) To deal with unstable "Key" Industries in the following way:—

A limited number of unstable "Key" industries will be scheduled, the products of which will be prohibited from importation into this country except on licence.

Pending legislation, a general licence under the Prohibition of Import Proclamations will be issued by the Board of Trade having effect as from September 1, 1919, and authorising the importation into the United Kingdom of all goods with the exception of those in the following list, which will be treated as unstable "Key" Industries: —

1. All derivatives of coar-tar generally known as intermediate products capable of being used or adopted for use as dyestuffs, or of being modified or further manufactured into dyestuffs. All direct cotton colours, all union colours, all acid colours, all chrome and mordant colours, all alizarine colours, all basic colours, all sulphide colours, all vat colours (including synthetic indigo), all oil, spirit, and wax colours, all lake colours, and any other synthetic colour, dyes, stains, colour acids, colour lakes, leuco acids, leuco bases whether in paste, powder, solution, or any other form.
2. i. Synthetic drugs (including antiseptics).
   ii. Synthetic perfumes and flavourings; synthetic photographic chemicals; synthetic tannins; esters and acid derivatives of aromatic hydrocarbons; alkaloids and their salts (except quinine); and the following organic chemicals:— Acetamide; acetic acid; acetic anhydride; acetyl chloride; camphor bromide; cinnamic acid and its salts; ethylene bromide; formamide; formic acid and its salts; gallic acid; lactic acid and its salts; nuclein; paraldehyde; pyrogallic acid; saccharine or other substances of like nature or use; salicin; thymol.
   iii. Analytical reagents; and the following fine chemicals:—Barium compounds; cerium fluoride and fluorides of other rare earth metals; hydrosulphites and allied bleaching compounds; hypophosphorus acids; iron and ammonium citrate; iron tartrate; molybdic acid and its salts: phosphorous oxides and halogen compounds; salts of per acids and artificial peroxides; silver nucleinate and proteinate; tungstic acid and its salts.
3. Optical glass, including lenses, prisms, and like optical devices.
4. Scientific glassware.
5. Illuminating glassware.
6. Laboratory porcelain.
7. Scientific and optical instruments.
8. Potassium compounds.
9. Tungsten powder and ferro-tungsten.
10. *Zinc oxide.*
11. Lithopone.
12. Thorium nitrate.
13. Gas mantles and mantle rings.
14. Magnetos.
15. Hosiery needles, latch.
16. Gauges.

In addition to the above, in pursuance of the undertaking given by the President of the Board of Agriculture in the House of Lords on March 19, 1919, the prohibition on the importation of hops will be continued for the present.

It is not proposed to make any addition to the above list unless and until Parliament so determine, with the possible exception that in the event of the contingency foreshadowed in paragraph (b) above arising it might be necessary to suspend temporarily all or any of the imports from the country affected by the collapse of exchange.

The Board of Trade understand that the notice issued by them to the Press on August 22 with reference to the interim administration of the Government's Key industry policy has led to some misapprehension.

Pending legislation a general licence under the Prohibition of Import Proclamations is to be issued to cover all goods with the exception of those set out in the list of Key industries.

In the case of kerosene and benzine (including white spirit), gas oil, and fuel oil, this general licence refers to total quantity of import, and does not affect the agreement entered into by the Government to limit the number of importing firms for the period of the existence of the *Pool Board, and nine months thereafter to those firms* which co-operated with the Government to form the Pool Board, as a result of which the community received material benefits.

The termination of the war organisation of the Pool Board as from January 31, 1919, was announced in the Press on January 2, 1919. The nine months period which has to elapse before other firms are allowed to import does not therefore expire until October 31, 1919.

Further, it should be noted that, in accordance with the provisions of Article 295 of the Peace Treaty, which requires all the parties to the Treaty to adopt the International Opium Convention, the importation of opium and cocaine except under Home Office licence remains prohibited.

NOTES.

INSTITUTE OF METALS.—An important addition has just been made to the list of papers that are to be presented at the annual autumn meeting of the Institute of Metals in Sheffield on Wednesday and Thursday, September 24 and 25. As originally published, the list included nine papers; there are now ten, the latest communication being a note by an American metallurgical engineer, Dr. Zay Jeffries, of Cleveland, Ohio, on "The Micro-Mechanism of the Ageing of Duralumin," a subject of great practical interest to all concerned with the working or use of an aluminium alloy that has played a vastly important part in aeronautical engineering during the war. Dr. Jeffries has come over in this country in order to be able to present his communication in person to the Institute at its Sheffield meeting, at which a record attendance of home and overseas members is assured. Copies of the note are now in the press and will be forwarded to all members and applicants for membership upon application being made to Mr. G. Shaw Scott, M.Sc., Secretary, Institute of Metals, 36, Victoria Street, S.W. 1, from whom also there can be obtained membership forms providing (in the event of success in the forthcoming ballot) for election in time for participation in the whole round of unique technical and social functions at Sheffield in cases where these forms are returned not later than noon on Wednesday next, September 10.

THE President of the Board of Trade has appointed Mr. W. J. Hands, O.B.E., to be Controller of the Profiteering Act Department. All communications in connection with the administration of the Act should be addressed to the Controller, Profiteering Act Department, 1, Queen Anne's Gate Buildings, Westminster, S.W. 1. Telegraphic address: Profactdep, Vic., London).

OPENING OF ATHENS EXHIBITION.—His Majesty King Alexander of Greece has graciously consented to open the Exhibition of British Manufactures organised by the Federation of British Industries in Athens. The exact date that will fit in with His Majesty's engagements is not yet known, but it is expected that it will be Sunday, October 19. This will be the public "gala" opening, but the exhibits will be arranged and the Exhibition open to trade visitors on the date already fixed October 13 (October 1 O.S). Apart from business the exhibition promises to be the great social event of the Athens season. Nothing approaching the Exhibition in importance and size has ever been held in Greece, and its novelty, together with the high patronage it is receiving, will make it the daily meeting place of Greek society. This will have its due effect on the business side of the Exhibition and will add greatly to the opportunities of exhibitors for making acquaintances and friendships valuable in the future.

SOCIETY OF LEATHER TRADES' CHEMISTS.—In view of the very important business to be transacted at the forthcoming Paris Conference it is hoped that as many members of the Society will be present as possible. The future well-being of the Society very largely depends on this Conference, which is to be held in Paris on Monday and Tuesday, September 22 and 23. Passports will be required for the journey, and early application should be made through Messrs. T. Cook and Sons, or your bankers. It will be necessary to obtain the visa of the French Consulate in London. It is hope to obtain facilities from the Board of Trade for this to be done *en bloc*, but if this should not be possible, then personal attendance at the French Consulate will be required, and a day must be allowed for this purpose. Those members who intend to be present should at once send in their names to the Hon. Sec., Mr. Stanley Hirst, 43, Woodbridge Road, Knowle, Bristol, from whom particulars of hotel accommodation in Paris can be obtained.

CITY OF LONDON COLLEGE,

WHITE STREET and ROPEMAKER STREET, MOORFIELDS, E.C. 2.

MICHAELMAS TERM commences SEPTEMBER 29th.

CLASSES and LABORATORY WORK in CHEMISTRY. Special preparation for the Examinations of the PHARMACEUTICAL SOCIETY. Courses on Commercial Products—Metals, Oils, Textiles.

Full particulars gratis on application to—

DAVID SAVAGE, Secretary.

THE POLYTECHNIC,

309, REGENT STREET, W. 1.

CHEMISTRY DEPARTMENT.

Head of Department—FRANK E. WESTON, B.Sc., F.I.C.

COURSES are arranged in—

1. PURE CHEMISTRY.
2. APPLIED CHEMISTRY.
   (*a*) Gas Manufacture and Engineering.
   (*b*) Fixed Oils, Fats, and Waxes.
   (*c*) Painters' Oils, Colours, and Varnishes.
   (*d*) Dairy Products.

Course 1 meets the requirements of the Conjoint Board Examination for Dental and Medical Students.

TERM commences SEPTEMBER 29. Enrolments from SEPT. 22.

Prospectus free on application to the DIRECTOR OF EDUCATION.

A Consulting and Analytical Chemist is prepared to take one or two PREMIUM PUPILS in either his Official or Private Laboratory.—Applicants, by letter, to M. A., 3, Caroline Place, W.C. 1, will receive conditions and terms.

B.Sc. (Vict.), 1919, desires Position as Assistant Chemist in Lancashire. Degree subjects: Chemistry and Botany, with Zoology (inter.). Some Works experience (during vacations), Nitric and Sulphuric Acids.—Address, Miss V., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist, three years' experience in large Tar Products Works before taking active service, now demobilised, desires Employment in London or the Provinces.—Address, T. T., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist, recently demobilised, three years' Technical College training and one year's Works experience, desires to communicate with firms as to suitable Appointment.—Address, O. C., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist, 26, demobilised, B.Sc. Hons. (Lond.), and knowledge of Bacteriology, seeks Employment in London.—Address, "C 26," CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Inter. B.Sc. (Boy, 18) desires Employment as Laboratory Assistant in any branch of Chemistry. North London preferred.—Address, A. F., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Lady Chemist (25) desires change of post, preferably in or near London. B.Sc. Hons. in Chemistry. Three years' Analytical experience.—Address, S. M. K., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

ITALIAN FIRM, dealing in CHEMICALS, in order to increase Wholesale Trade (especially products for Industry), desires to get connected with first-class British Commission Agent in a position to give keen quotations directly from Makers or Importers. Disposed to make arrangements for Sole Agency after trial period.—Write full particulars, indicating references, to "Boffa," Casella Postale 230, Torino, Italy.

The Proprietors of PATENTS Nos. 101973 and 126039,—

"PREPARATION OF BENZENE MONOSULPHONIC ACID,"

desire to negotiate with one or more firms in the United Kingdom, for the Sale of the Patent Rights or for the grant of Licences to manufacture under royalty.

Enquiries should be addressed to—

Messrs. FEENY and FEENY,
60, QUEEN VICTORIA STREET, LONDON. E.C.

FOR SALE.

Steam-heated VACUUM EVAPORATING PLANT, complete with evaporating cylinder, 5 ft. diameter by 14 ft. long, and Vacuum Pump driven by Steam Engine. Full particulars on application.—Address, R. W., CHEMICAL NEWS Office, 16, Newcastle Street, Farringdon Street, London. E.C. 4.

BATTERSEA POLYTECHNIC,

LONDON, S.W. 11.

The Governing Body invite applications for the following Appointments:—

Two TEMPORARY ASSISTANT LECTURERS AND DEMONSTRATORS IN CHEMISTRY, from SEPTEMBER to DECEMBER, 1919. Inclusive salary for the period £75.

For particulars send stamped addressed envelope to the SECRETARY.

CITY OF BRADFORD EDUCATION COMMITTEE.

BRADFORD TECHNICAL COLLEGE.

DEPARTMENTS OF
CHEMISTRY, DYEING, & NATURAL SCIENCE

DIPLOMA COURSES, extending over four years, and PART-TIME COURSES are offered.

SESSION commences SEPTEMBER 22.

Prospectuses of above, and of Courses in TEXTILE INDUSTRIES and ENGINEERING, may be obtained on application.

BY ORDER.

THE CHEMICAL NEWS

VOL. CXIX., No. 3100.

(STUDENTS' NUMBER).

UNIVERSITIES AND COLLEGES.

UNIVERSITY OF LONDON.

CANDIDATES for any Degree in this University must either have passed the Matriculation Examination in this University, or be admitted under the Statute which provides that the Senate may admit graduates of or persons who have passed the examinations required for a degree in other Universities approved by it. This and all other Examinations of the University, together with the Prizes, Exhibitions, Scholarships, &c., are open to Women upon exactly the same conditions as to Men.

There are three Examinations for Matriculation in each year; commencing on the second Monday in September, January, and June or July, as may hereafter be determined.

Every Candidate for the Matriculation Examination must apply to the Principal for a Form of Entry on or before August 20, which must be returned fourteen days before the commencement of the September Examination; or must apply for a Form of Entry on or before November 25, which must be returned on or before December 1, for the January Examination; or must apply for a Form of Entry on or before April 25, which must be returned on or before May 1, for the June (or July) Examination; accompanied in each case by the proper Fee, and by a Certificate showing that the Candidate will have completed his Sixteenth Year on or before January 14 for the January Examination, July 31, the end of the Secondary School Year, for the June Examination, and September 15 for the September Examination.

Every candidate entering for the Matriculation Examination must pay a Fee of £2.

Intending Students (Internal and External) should obtain the "Regulations and Courses" from the Registrar, University of London, South Kensington, S.W.

Several valuable Scholarships and Exhibitions are available to students.

UNIVERSITY OF OXFORD.

Waynflete Professor of Chemistry—W. H. Perkin, M.A., F.R.S.

Every Student must reside in one or other of the Colleges or Halls, or in licensed lodgings, for a period of three years. Students of Chemistry can obtain the degree of B.A. by passing preliminary examinations in Arts and in Science, and a final Honour examination in Chemistry. Chemistry may also be taken as part of the examination for a Pass degree. Graduates of other Universities and other persons suitably qualified can obtain the degree of Bachelor of Science after an approved course of study or research and two years' residence.

University Laboratory.—The fee for students working in the Laboratory for three days in the week during the Term is £3; for students working every day, £5.

There are also laboratories which specialise in different parts of the subject:—*Physical Chemistry*, Balliol and Trinity College Laboratory. *Inorganic Chemistry*, Christ Church Laboratory. *Quantitative Analysis*, Magdalen College Laboratory, Jesus College Laboratory. *Organic and General Chemistry*, Queen's College Laboratory.

Numerous Scholarships, usually of the value of £80 per annum and tenable for four years, are offered every year by the various colleges. They are awarded after a competitive examination in the various branches of Natural Science.

More detailed information may be obtained from the Examination Statutes; the Student's Handbook to the University; and from the professors and college tutors.

UNIVERSITY OF CAMBRIDGE.

Professor of Chemistry—Sir William J. Pope, K.B.E., M.A., F.R.S.

Jacksonian Professor of Natural and Experimental Philosophy—Sir James Dewar, M.A., F.R.S.

Goldsmiths Reader in Metallurgy—Charles T. Heycock, M.A., F.R.S.

The Student must enter at one of the Colleges or Hostels, or as a Non-collegiate Student, and keep terms for three years by residence in the University. He must pass the previous examination in Classics and Mathematics, which may be done in any term of residence or before commencing residence. He may then proceed to take a Degree in Arts, either passing the ordinary examinations or B.A., or going out in one of the Honour Triposes.

A graduate of another University may be admitted as a Student of Research, and obtain a degree after two years' residence in the University, by presentation of a thesis describing original research.

Facilities for research work are provided both in the Chemical Laboratories and in the Metallurgical Laboratories.

The scholarships range in value from £20 to £100 a year. Scholarships, or Exhibitions, are given for Natural Science at the several Colleges; the dates of the examinations vary, but are always fully advertised.

The Chemical Laboratories of the University are open daily for the use of the Students. The Demonstrators attend daily to give instruction. A list of the lectures and practical courses is published annually, in June, in a special number of the *Cambridge University Reporter*, which may be had from the Cambridge Warehouse, in Paternoster Row, or through any bookseller.

Non-collegiate Students are allowed to attend certain of the College Lectures and all the Professors' Lectures, and have the same University status and privileges as the other Students. Full particulars may be obtained by forwarding a stamped directed envelope to the Assistant Registrary, Cambridge, from the *Cambridge University Calendar*, or from the "Students' Handbook to Cambridge."

UNIVERSITY OF DUBLIN.
TRINITY COLLEGE.

Professor of Chemistry—Sydney Young, D.Sc., F.R.S.

Professor of Applied Chemistry—Emil A. Werner, Sc.D., F.C.S., F.I.C.

Demonstrator—W. C. Ramsden, F.C S.

Junior Demonstrator—J. Bell.

The general Quantitative and Research Laboratories include working accommodation for about 130 Students. The Laboratories will open on October 1st. Lectures will commence on November 3rd.

The Laboratories and the Lectures of the Professor of Chemistry can be attended by Students who do not desire to reside in the University or proceed to its Degrees.

The full Course of General and Analytical Chemistry occupies three years, but a Student is free in his third year to devote most of his time to a special department of Pure or Technical Chemistry. Students can enter for any portion of the Course. The Lectures delivered are:—

1. *Inorganic Chemistry and Chemical Philosophy.*— Elementary, first year; Advanced Inorganic Chemistry, second year; Physical Chemistry, third year.
2. *Organic Chemistry.*— General, second year; advanced, third year.
3. *Metallurgy.*—A Course for Engineering and Technical Students.
4. *Agricultural Chemistry.*—Theoretical and Practical Courses.

The Laboratories are open every day from 10 to 5 o'clock (except Saturdays, when they close at 1 o'clock).

The Summer Course of Practical Chemistry for Medical Students begins early in April and terminates about the beginning of June.

A special course for Dental Students will be given.

The University of Dublin grants the Degree of Doctor of Science to graduates of Master's standing whose independent researches in any branch of Science are of sufficient merit.

The University also grants the Degree of Bachelor of Science to graduates who have obtained Moderatorshid or an Honours Degree equivalent to Moderatorship and have devoted a year to research in the University Laboratory.

Prizes in Chemistry and Physics are givenat the October (Arts) Entrance Examination, and also at the Terminal Examinations of the Junior and Senior Freshmen Years.

Similarly, two Science Scholarships will be obtainable by Undergraduates, and tenable for five years. The Foundation Scholars receive £20 per annum, they have free commons, and their chambers for half the charge paid by other students; their tutorial fees are at one-fourth the usual rates.

KING'S COLLEGE.
(UNIVERSITY OF LONDON).

Professors—A. W. Crossley, C.M.G., Ph.D., F.R.S., &c. (Daniell Professor); A. J. Allmand, D.Sc.

Lecturers and Demonstrators—L. E. Hinkel, B.Sc., Stephen R. H. Edge, B.A., Donald G. Browning B.Sc.

The Academical Year consists of Three terms. The days fixed for the commencement of Terms in 1919-1920 are Oct. 1, Jan. 14, and April 28.

The general Courses of Lectures on Chemistry deal with the nature and scope of the subject and the principles involved, in relating to one another the experimental facts, shown as illustrations of the properties of the elements and their chief compounds. The non-metallic elements are first treated of, as demonstrating most clearly the characters of the interactions between the different kinds of matter, and as affording the best opportunity of classifying the main groups of compounds met with, when dealing with the inorganic branch of the subject. The metallic elements and their compounds are then discussed, and this part of the Course is completed with a *résumé* in which the connected relations of the properties of the elements are described. The latter portion of the Course embraces in the same manner a study of the principles and properties of the carbon compounds which are examples of the main groups of organic substances. Class Examinations are held from time to time during the Session.

Experimental and Analytical Chemistry in the Laboratory.—The object of this Class is to afford to Students who are desirous of acquiring a knowledge of analysis, or of prosecuting original research, an opportunity of doing so under the superintendence of the Professor and Demonstrator; Students may enter, upon payment of extra fees, at any time except during the vacation, and for a period of one, three, six, or nine months, as may best suit their convenience. The laboratory hours are from ten till five daily, except Saturday.

In addition to the Laboratory Fee, each Student defrays the expenses of his own experiments. The amount of this expense, which is comparatively trifling, is entirely under his own control.

For fuller details the separate Syllabuses provided for each class should be consulted.

War Students.—Students who (i.) have served in His Majesty's Forces, (ii.) have undertaken other service approved by the University in connection with national defence, or (iii.) have been interned as civilian Prisoners of War, will be entitled to present themselves for Intermediate and Final Examinations under special conditions. Students included in the categories enumerated above will be termed "War Students." For full particulars application should be made to the Assistant Principal of the College.

UNIVERSITY COLLEGE.
(UNIVERSITY OF LONDON).

Professors—J. Norman Collie, Ph.D., F.R.S. (Organic Chemistry); F. G. Donnan, M.A., F.R.S. (Inorganic and Physical Chemistry).

Assistants—Katharine A. Burke, B.Sc.; W. B. Tuck, D.Sc.; Irvine Masson, M.B.E., D.Sc.; H. Terrey, B.Sc.; E. K. Rideal, M.B.E., D.Sc.

The Session is divided into three Terms, as follows:—First Term, from September 29 to December 17; Second Term, from January 13 to March 20; Third Term, from April 27 to July 1.

Introductory Course of Inorganic Chemistry.

Tuesday and Thursday, at 11. Practical, Thursday, 2 to 3.30, or 3.30 to 5. Fee—Session, £10 10s.; Term, £4 4s.

A course of Elementary Inorganic Chemistry, adapted to the requirements of students of Engineering.

Junior Course of Inorganic Chemistry.

An Introduction to the Principles of Inorganic Chemistry. Special attention will be paid to general points of view, and to the application of physico chemical laws and methods.

First and Second Terms: The Class meets on Mondays, Wednesdays, Fridays, and Saturdays, at 9, for Lectures, Examinations, and Exercises.

Third Term: Lectures will be given on Mondays and Fridays at 9, and Wednesdays at 11.

Fees: Course, £7 7s.; First or Second Terms, £4 4s.

A Practical Class will meet throughout the Session.

Senior Course of Physical Chemistry.

Tuesday and Thursday at 9.

A general Course on Physical Chemistry and its applications. Fee:—Course, £5 5s.

General Course of Organic Chemistry.

Monday and Wednesday at 12, Thursday at 3.

Fees:—For the Course, £6 6s.; for a Term, £2 12s. 6d.

An Advanced Course will be held twice a week throughout the Session for those engaged in prosecuting research in Organic Chemistry. Monday and Friday at 11. Fee, £5 5s.; Term, £2 2s.

Practical Classes.

Practical Classes in Inorganic and Organic Chemistry are conducted by the Assistants.

Laboratories of General and of Organic Chemistry.

The Laboratories are open daily from 9 a.m. to 5 p.m., Saturdays excepted, from October until the middle of July, with a short recess at Christmas and at Easter.

Fees: for the Session, £26 5s.; six months, £18 18s.; three months, £10 10s.; one month, £4 4s.

Three specified days a week:—for the Session, £15 15s.; six months, £11 11s.; three months, £6 6s.; one month, £2 12s. 6d., exclusive of expense of materials. Students may enter at any period of the Session.

When accompanied by, or preceded by, attendance on the Lectures and Practical Classes in Inorganic and Organic Chemistry, the Laboratory Courses qualify Students in the application of Chemistry to Manufactures, Metallurgy, Medicine, or Agriculture, &c.

There is also a Chemical Library containing the chief Journals and Standard Works on Chemistry.

Certificates of Honour are granted to competent Students on the work done during the Session. Several valuable Scholarships are available to students.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY.

Emeritus Professors—Sir W. A. Tilden, D.Sc., F.R.S., and Sir T. E. Thorpe, C.B., F.R.S., &c.

Professor and Director of the Chemical Laboratories.—H. Brereton Baker, C.B.E., D.Sc., F.R.S., &c.

Professor of Chemical Technology and Fuel Chemistry—W. A. Bone, F.R.S.

Professor of Organic Chemistry—J. F. Thorpe, C.B.E., F.R.S.

Professor of Physical Chemistry—J. C. Philip, O.B.E., M.A., D.Sc.

Assistant Professor—B. Mouat Jones, M.A., D.S.O.

The Imperial College of Science and Technology, incorporated under the Royal Charter of July 8, 1907, is an institution or group of associated colleges with its principal seat at South Kensington.

The purposes of the Imperial College are to give the highest specialised instruction, and to provide the fullest equipment for the most advanced training and research in various branches of science, especially in its application to industry; and to do all and any of such things as the Governing Body consider conducive or incidental thereto, having regard to the provision for those purposes which already exists elsewhere.

For these purposes, the Governing Body, subject to the provisions of the Charter, are to carry on the work of the Royal College of Science, and the Royal School of Mines, and may establish Colleges and other Institutions or Departments of Instruction. Any Institution or Department so established, and, subject to the conditions of the Charter, the Central Technical College of the City and Guilds of London Institute, are to be integral parts of the Imperial College; and the Central Technical College is to be called and known in future as the City and Guilds College.

The Charter further provides that the Imperial College shall be established in the first instance as a School of the University of London. Students of the Imperial College who have matriculated at the University of London may therefore proceed to the Science degree of the University as "Internal Students."

Attention is particularly directed to the conditions of admission and to the extended facilities for Research Work.

The ordinary courses of instruction are planned so as to extend over four years, and are generally similar for all divisions during the first year, and to a less extent during the second year, after which they are specialised according to the particular course which the student is taking.

A semi-large scale laboratory is now being built in which students will be familiarised with processes beyond the laboratory scale.

The following Diplomas are awarded to Students of the several constituent Colleges:—

The Diploma of the Imperial College of Science and Technology (D.I.C.) for advanced study or research in Pure or Applied Science.

The Associateship of the Royal College of Science (A.R.C.S.) in one or more of the following divisions:—Mechanics, Physics, Chemistry, Botany, Zoology, Geology

The Associateship of the Royal School of Mines (A.R.S.M.) in one or more of the following divisions:—Metallurgy, Mining.

The Associateship of the City and Guilds Institute, (A.C.G.I.) in Engineering (Civil and Mechanical), Engineering (Electrical).

Twelve entrance scholarships are given in September each year, and post graduate scholarships are available for enabling fourth and fifth year students to complete their courses. Three Research Fellowships, founded by Mr. Otto Beit, of £150 a year, tenable at the Imperial College, are offered annually to post graduate students of this College, as well as to graduates of other Universities.

Full details can be obtained from the College Calendar, published by Eyre and Spottiswoode (or through any bookseller), price 6d.

THE SCHOOL OF PHARMACY OF THE PHARMACEUTICAL SOCIETY OF GREAT BRITAIN.

Professor—Pharmaceutics, Henry G. Greenish, F.I.C., F.L.S. (Dean); Lecturers—Chemistry, C. E. Corfield, A.I.C.; Botany, J. Small, M.Sc; Micro-Biology, Albert E. Parkes, F.I.C.

A Course of Lectures on Physical, Inorganic, and Elementary Organic Chemistry, Botany, Materia Medica, and Pharmacy commences in October and terminates at the end of June. An Advanced Course of Lectures begins in October and extends to the end of March. These Lectures are adapted to the requirements of Pharmaceutical and Medical Students, and also of those who are proceeding to degrees at the University of London, or who are preparing for the examinations of the Institute of Chemistry.

Entries may be made for single classes. Certificates of attendance at the Lectures and Practical Work in Chemistry and in Botany are accepted as evidence of scientific training by the Institute of Chemistry in connection with the Examinations for the Associateship. Certificates of attendance at the Lectures and Practical Work in Chemistry are accepted by the Conjoint Board of the Royal Colleges of Physicians and Surgeons, as well as by other examining bodies. Certificates of attendance at the Course of Pharmacy are also accepted by the Conjoint Board, and at the Courses of Pharmacy and Materia Medica by the University of London for the Second Examination for Medical Degrees, Part II.

Prospectuses and further information may be obtained from the Dean of the School, 17, Bloomsbury Square, London, W.C.

UNIVERSITY COLLEGE OF WALES, ABERYSTWYTH.

UNIVERSITY OF WALES.

Professor—A. Findlay, M.A., D.Sc. (Aberdeen), Ph.D. (Leipzig), F.I.C.

Lecturer and Demonstrator—T. Campbell James, M.A. Trinity College, Cambridge, D.Sc. (Wales), F.I.C.

Assistant Lecturer and Demonstrator—C. R. Bury, B.A., B.Sc.

Lecture Assistant—(Vacant).

Student Assistant—(Vacant).

Lecturer in Agricultural Chemistry—J. Jones Griffith, B.Sc. (Wales).

The College is open to men and women students above the age of sixteen years. The Session commences on Oct. 1st, on which day all Students will be expected to meet the Professors in the Examination Hall of the College.

Lecture Courses.—(1) Intermediate Science Course; four lectures weekly throughout the Session. (2 and 3) B.Sc. Courses; A, three lectures weekly on Organic Chemistry; B, three lectures weekly on General and Physical Chemistry. (Courses A and B will generally be given in alternate Sessions; for 1918-1919, Course B). (4 and 5) Courses in Agricultural Chemistry. For students in their first year, 3 lectures, and for those in their 2nd year, 2 lectures weekly during the Michaelmas and Lent terms.

Laboratory Courses.—The Laboratories are open daily from 9 a.m. to 1 p.m. and from 2 to 6 p.m., Saturdays 9 a.m. to 1 p.m. Regular Courses of practical work, suitable for the B.Sc. degree of the Universities of London and Wales, or for the Associateship of the Institute of Chemistry, can be followed. Facilities are given for Students wishing to undertake research work. Special Courses will be arranged for those who intend to follow Medicine or Pharmacy, or any one particular branch of Applied Chemistry, always provided that such Students possess the requisite knowledge of Theoretical Chemistry. The hours will be arranged, as far as possible, to suit the requirements of the individual Student.

The College is recognised by the University of Edinburgh and the Royal University of Ireland, and by the Colleges of Physicians and Surgeons of England, Scotland, and Ireland as an institution at which the instruction necessary for their respective Diplomas in Medicine, in Chemistry, Physics, and Biology may be given. One year for graduation in Medicine and two years for graduation in Science may be spent at Aberystwyth.

Fees.—The Fee for the whole Session, if paid in advance, is £17. This composition fee enables the Student to attend any or all the Classes and Laboratories of the College.

Scholarships and Exhibitions varying in value from £10 to £40 per annum will be offered for competition at examinations which commence on September 19, and exhibitions are awarded at the end of the Session on the results of the class examinations.

Intending Students requiring further information are recommended to write to the Registrar for a copy either of the General Prospectus or of one of the Special Prospectuses issued for the Agricultural and Normal Departments.

UNIVERSITY COLLEGE OF NORTH WALES, BANGOR.

A Constituent College of the University of Wales.

Chemistry.—Professor, K. J. P. Orton, M.A., Ph.D., F.I.C. Lecturer, Eric Robinson, B Sc. Assistant Lecturers, H. B. Watson, B.Sc., Miss McDougall, B.Sc.

Agricultural Chemistry.—Lecturer, G W. Robinson, M.A. Assistant Lecturer, W. E. Lloyd, B.Sc.

Physics.—Professor, E. Taylor Jones, D.Sc.

The Session opens October 1st, 1919. All regular classes are open to men and women students above the age of 16 years. The following Courses of Lectures will be given.

Intermediate Course.—Inorganic Chemistry and Elementary Physical Chemistry. Fee for the Session, £5.

B.Sc. Course.—Inorganic Chemistry. Fee for the Session, £3 15s. Advanced Lectures on Organic Chemistry, £1 5s. Physical Chemistry, £1 5s.

Agricultural Chemistry.—Fee, £2 10s.

Laboratory Courses.—The laboratory is open on five days of the week from 9 a.m. to 5 p.m. Fees: six hours per week, £1 1s. per Term; twelve hours, £2 2s.; Composition Fee for all Lectures and Laboratory Classes of the Science Degree Course taken in one year, £16.

The College Courses are arranged with reference to the Degree Courses of the University of Wales (of which the College is one of the Constitutent Colleges). The Courses in Science are also suited to the requirements of Students preparing for the Science Degree Course of the University of London, and for the Associateship of the Institute of Chemistry.

The Chemistry, Botany, Zoology, and Physics Courses are recognised for Medical graduation in the Universities of Edinburgh and Glasgow, and by the Conjoint Boards of the Royal Colleges of Surgeons and Physicians, and students can make one *Annus medicus* at the college. Students are prepared for the First Examination of the Universities mentioned, the First Examination for Medical Degrees of the University of London, and of the Conjoint Board of the Royal Colleges of Surgeons and Physicians. The Science Courses are recognised for part of the science degree course of the University of Edinburgh.

UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE, CARDIFF.

Professor of Chemistry—C. M. Thompson, M.A., D.Sc., F.C.S.

Assistant Professor—E. P. Perman, D.Sc., F.C.S.

Lecturer in Organic Chemistry—H. Ll. Bassett, B.A., B.Sc.

Lecturer to Medical Students and Demonstrator—F. W. Rea, B.A., M Sc.

Professor of Metallurgy—A. A. Read, D.Met., F.I.C.

The Session commences October 7th and terminates on June 25th, and is divided into three terms.

The Junior Course (delivered during the Michaelmas term only) consists of about 30 lectures, and will cover the subjects prescribed for the Matriculation examinations of the University of Wales and the University of London.

The Intermediate Course consists of about 80 lectures; together with laboratory practice it forms the qualifying course for the Intermediate Examination of the University of Wales, and will cover the subjects required for the Intermediate Examination in Science (Part I.) of the University of London.

The Senior Course consists of about 80 lectures on Organic Chemistry.

A course on Inorganic Chemistry will be given in the Session 1920-1921.

In the laboratory each student works independently, so that the course of study may be adapted to the requirements of the individual. Hours, 9 to 1 and 2 to 5; Saturday, 9 to 1. Fees—Six hours per week, £4 per session; eight per week, £6 6s. per session; twelve hours or more per week, £8 8s. per session.

Registered medical students can prepare for the Intermediate M.B. Examination of the University of London, and spend three out of their five years of medical study in Cardiff. Medical students preparing for a Conjoint Board Surgical and Medical Diploma, or for the Diploma of the Society of Apothecaries, can spend two years in Cardiff, For further information see the prospectus of the Faculty of Medicine, which may be obtained from the Registrar.

Students by making a payment of £16 at the commencement of each session may compound for all fees for the whole session.

At the entrance examination in April, and the annual examination in June, several scholarships and exhibitions are awarded. Great importance is attached to special excellence in one subject.

The College Prospectus, and also further information as to scholarships, may be obtained from the Registrar.

A special prospectus is issued concerning courses of study for diplomas in engineering, mining, and metallurgy.

A Hall of Residence for Women Students is attached to the College.

UNIVERSITY OF BRISTOL.

Department of Chemistry.

Alfred Capper Pass Professor of Chemistry—Francis Francis, D.Sc., Ph.D., F.I.C.

Lecturers—O. C. M. Davis, B.Sc., D.Sc., M.B., F.I.C.; F. W. Rixon, M.Sc., PhD.

Lecturer in Physical Chemistry—James W. McBain, M.A., Ph.D.

Lecturer in Bio-chemistry—M. Nierenstein, Ph.D., D.és Sc.

Lecturer in Hygienic Chemistry—Edward Russell, B.Sc., F.I.C.

Laboratory Steward—J. H. Sturgess.

The session commences on October 1.

The Department of Chemistry is situated in the new wing of the University Buildings in Tyndall's Park, and was opened on October 1, 1910. The Department provides accommodation for 200 students, and laboratories for work in specialised branches of Chemistry have been designed and equipped with apparatus of the most modern type. All the laboratories are supplied with electric wiring for experimental purposes, and currents of any desired voltage up to 250 volts at 50 ampères from dynamo or storage cells may be obtained throughout the Department. Higher voltages and currents are available in special laboratories, for Physical Chemistry and Electro-metallurgy. Special facilities are afforded to those who desire to carry out research or to study Chemistry as applied to the different processes employed in the arts and manufactures; and a laboratory for Bio-chemistry has been specially designed for the investigations of problems on Biological lines.

Day Lectures.

General Courses.—1. General Inorganic Chemistry—Three lectures per week during Session and Laboratory work. 2. General Organic Chemistry—Three Lectures per week during one Session and Laboratory work. 3. Physical Chemistry—Three Lectures per week for first Session, two Lectures per week for second Session, and Laboratory work.

The Laboratories are open daily from 9.30 to 5 except on Saturdays, when they are open for Senior Students only.

Courses for Graduation.—Intermediate Science—Course 1 and one day Laboratory per week. *Pass Degree*—,

Course 2 and 3, and at least one day Laboratory per week during two Sessions. The Chemical Society must be attended during the second and third years, and one or more of the Special Courses arranged for Honours Students. *Honours Degree*—Four year course, or three in the case of those who already hold a Higher School Certificate. The last session is spent on research which is essential for all Honours Degrees in the Faculty of Science. During the first year in the Honours School Courses 2 and 3, and the second and third, Course 3, and one or more of the following Special Courses as directed, *e.g.*:—Organic Chemistry, Physical Chemistry, Mathematical Chemistry, Advanced Inorganic Chemistry, Applied Electro-chemistry, some part of Bio-chemistry.

The meetings of the Chemical Society must be attended during each Session.

Colloquium.—A weekly Colloquium will be held by members of the Staff to discuss recent advances in the various developments of Chemistry. Honours Students attend, and others interested are invited to do so.

Extract from Regulations as Regards Fees.

1. Registration Fee 7s. for a single Course; £1 1s. shall cover a perpetual registration for any number of Courses.

2. Inclusive Fee for an entire curriculum for degree of B.Sc., whether "Pass" or "Honours," shall be £21 a year.

The Fees for separate Laboratory practice and instruction in the Faculty of Science shall be at the rate of £2 2s. per term for each day in the week for which admission in the Laboratories is sought, with a minimum of £3 3s. in each particular case.

The scale of fees for separate courses of lectures in the Faculty of Science may be obtained on application.

All communications to the University to be addressed to the Registrar. Information concerning Courses or Laboratory work in the Department of Chemistry may be obtained from the Professor.

The department of Experimental Physics includes various courses of lectures arranged progressively, and practical instruction is given in the physical and electrical laboratories. The Faculty of Engineering includes courses specially arranged for students intending to become civil, mechanical, electrical, or automobile engineers. Medical education is provided by the Faculty of Medicine of the University. Several Scholarships are tenable at the University.

MERCHANT VENTURERS' TECHNICAL COLLEGE, BRISTOL.

Chemistry.

Professor—J. Wertheimer, B.A., D.Sc., F.I.C., F.C.S.

Lecturers—H. A. M. Borland, A.R.C.S.; H. Stanley, B.Sc., F.I.C.; H. F. Barke, F.I.C.

Laboratory Steward—Mary R. Saunders.

Assistant in Chemical Laboratory—H. Hooper.

The following Evening Classes in Chemistry are held:—Preliminary Inorganic, Mondays, 7.10—9.15; Matriculation (Inorganic), Fridays, 7.0—9.40; Intermediate (Inorganic), Tuesdays, 7.10—9.15. They will begin on Monday, Sept. 29th, 1919.

UNIVERSITY OF BIRMINGHAM.

[Up to the time of going to press we had not received the necessary particulars from this University. To ensure accuracy it would be advisable, therefore, to communicate direct with the Registrar].

Professor of Metallurgy—Thomas Turner, M.Sc., A.R.S.M.

The Session will be opened on October 1st, 1919.

The Chemical Department has hitherto been housed in the new University buildings at Bournbrook, but owing to those buildings having been taken over by the Military Authorities for use as a Base Hospital the classes during the coming Session will be arranged for at the Birmingham Municipal Technical School and the Mason College.

Lecture Courses.

First Year.—A. This part of the course is arranged (1) to give a full exposition of the general principles of Chemical Science, (2) for the systematic study of the properties of the more important elements and their compounds, and (3) to indicate the chief applications of Chemistry in the Arts and Manufactures. Three hours weekly during the Winter and Spring terms. Mondays, Wednesdays, and Thursdays at 9.30 a.m. Fee, £5 5s. B. This part of the course includes an introduction to the study of Organic Chemistry, with a description of the properties, relations, and methods of preparation of the more important groups of Carbon Compounds. Three hours weekly during the Summer term. Mondays, Wednesdays, and Fridays, at 9.30 to 10.30 a.m. Fee, £1 11s. 6d.

Second Year.—*Advanced Organic Chemistry.*—This course extends over two years, and is divided into two parts:—(*a*) Carbon Compounds of the Fatty Series; (*b*) Aromatic and other Cyclic Compounds. Only one of these parts will be taken in each year. The class meets twice weekly by arrangement during the Winter and Spring terms. Fee, £2 2s. *Advanced Inorganic Chemistry.*—This course is devoted to the consideration of special branches of Inorganic Chemistry, and direction is also given as to the private reading which should be pursued by students. The class meets by arrangement once weekly during the Session. Fee, £1 1s.

Third Year.—A further Course in Advanced Organic Chemistry will deal with one of the above parts of the Course. The class meets two hours weekly by arrangement during the Winter and Spring terms. Fee, £2 2s. A Course on Physical Chemistry. Fee, £2 2s.

The class meets two hours weekly during the Winter and Spring Terms.

Fourth Year.—For students preparing for the B.Sc. degree with Honours in Chemistry.

Special Courses in General, Organic, and Physical Chemistry.

Practical Chemistry.

The instruction in Practical Chemistry Inorganic, Organic, and Physical) extends over four years in the case of the Honours Degree. The Laboratory will be open daily from 9.30 to 5, except Saturdays, when it closes at 1 p.m. Fees—

	All day.	Three hours per day.	Three hours per day; five days a week.	Three hours per day; three days a week.
	Guineas.	Guineas.	Guineas.	Guineas.
One Term ..	7	4½	4	2½
Two Terms .	13	8½	7½	5
Three Terms	18	12	11	6½

Special facilities are given to Advanced Students for the prosecution of original research.

Metallurgy.

There is a separate University department for Metallurgical students in which provision is made for instruction in assaying, &c.

Scholarships.

Priestley Scholarships.—Three Open Scholarships in Chemistry of the value of about £96 each are awarded annually in June.

Ascough Scholarship.—One Open Scholarship of the value of about £30 is awarded annually in July.

Bowen Scholarship.—One Open Scholarship in Metallurgy, value about £96, is awarded annually in June.

For particulars apply to the Registrar.

CITY OF BRADFORD TECHNICAL COLLEGE.

Principal—Prof. W. M. Gardner, M.Sc., F.I.C.

Department of Chemistry.

Professor of Chemistry—(Appointment pending).

Lecturers in Chemistry—L. L. Lloyd, Ph.D.; H. P. Starck, B.A.; H. Middleton, M.Sc.; E. Jones, B.Sc.

Lecturer in Physics—J. A. Tomkins, A.R.C.S. (Lond.).

Demonstrator in Physics—F. Harcourt, B.Sc.

Lecturer in Gas Manufacture—J. W. Roper.

Department of Biology.

Head of Department—A. M. Smith, M.A.

Lecturer in Pharmacy—G. H. Etchells.

Department of Dyeing.

Head appointment pending.

The following courses of instruction are provided —

I. *General Chemistry Course*, extending over four years, and including Lectures in Inorganic, Organic, and Technological Chemistry, Principles of Analysis, Technical Analysis, Electro-chemistry, Physical Chemistry, Physics, Mathematics, Mechanics, with Laboratory work in Chemistry and Physics.

II. *Chemistry and Dyeing Course*, extending over four years. Includes most of the above subjects, along with Lectures and practical work in Dyeing, Colour matching, &c. The practical laboratories include a completely equipped Practical Dyehouse and Finishing Rooms.

III. *Chemical Engineering*. Three years' course, preparing Students for positions in Chemical Works, Sewage Works, &c.

IV. *Sanitary Science*. One year's Course, recognised by the Sanitary Institute as preparing for their certificate examination. Subjects: Chemistry, Physics, Sanitary Engineering, Sanitary Law, Building Construction, Drawing, Physiology, and Bacteriology.

V. *Dyeing*. Special Courses for Graduates in Chemistry, and for Drysalters, Colour Merchants, &c.

VI. *Textile and Dyeing*. Arranged for those Students who desire to study the two subjects simultaneously.

VII. *First Professional Examination, Conjoint Medical Board* (*M.R.C.S., L.R.C.P.*), *London*.—Attendance at the College and College Certificates in Chemistry, Physics, and Biology are recognised by the Conjoint Boards for Medical Studies (London and Dublin) as a qualifying curriculum.

VIII. *General Pharmaceutical Course*. Prepares for the Minor, Major, and Assistants' Pharmaceutical Examinations. Each extends over two years on four half-days per week, and includes Chemistry and Physics, Botany, Biology, Materia Medica, Pharmacy, and Dispensing.

THE UNIVERSITY OF LEEDS.

Professor of Chemistry—Arthur Smithells, C.M.G., F.R.S.

Professor of Organic Chemistry—Julius B. Cohen, Ph.D., B.Sc., F.R.S.

Lecturer on Physical Chemistry—H. M. Dawson, D.Sc., Ph.D.

Lecturer in Analytical Chemistry—W. Lowson, B.Sc., F.I.C.

Assistant Lecturer and Demonstrator—(Vacant).

Demonstrator in Organic Chemistry—P. H. Dutt, M.A., M.Sc.

Lecture Courses.

1. General Course of Chemistry.—Monday, Wednesday, and Friday, at 11.30 a.m. Fee for the Course, £5 10s.

2. Advanced Inorganic Chemistry. — (A) Monday, Wednesday, and Friday, at 9.30 a.m. Fee, £4 10s.

3. Advanced Inorganic Chemistry. — (B) Tuesday, Thursday, and Saturday, at 9.30 a.m. Fee, £4 10s.

4. Organic Chemistry. — Tuesday, Thursday, and Saturday at 11 30 a.m. Fee, £4 10s.

5. Honours Courses —(*a*) Organic Chemistry: Monday, Wednesday, and Friday at 11.30 a.m.; fee, £4 10s. (*b*) History of Chemistry: Monday, Wednesday, and Friday at 9.30 a.m. in the First Term; fee, £2 5s. (*c*) Physical Chemistry: Three hours a week at times to be arranged; fee, £4 10s. (*d*) Electro-chemistry: Tuesdays at 9.30 a.m.; £2 10s.

9. Chemistry of Food and Drugs —Special class during the second term for Students taking Final Examination of the Institute of Chemistry in Branch E (Food and Drugs). £3 3s.

Laboratory Courses.

The University Laboratory will be open daily from 9 a.m. to 1 p.m., and from 2 to 5 p.m., except on Saturdays, when it will close at 1 p.m.

Fees for the Session—£3 per half day of three hours per week.

Practical Course in Sanitary Chemistry.—Tuesdays and Thursdays from 2 to 5 in the Second and Third Terms, Fee, £7 7s.

Colour Chemistry and Dyeing Department.

Professor—A. G. Perkin, F.R.S., F.I.C.

Lecturer and Research Chemist—J. B. Oesch, Ph.D.

Lecturer in Dyeing and Research Assistant—P. E. King.

Assistant Lecturer and Demonstrator—H. G. Crabtree.

Demonstrator—E. J. Cross.

The Courses extend over periods of (*a*) three or (*b*) four years, and are intended for those who wish to obtain a full scientific and practical education in the art of dyeing, colour manufacture, &c. Diploma Course (*a*) is suitable for those who purpose to become dyeing chemists, and desire in the future to take part in the direction of the operations of dyeing and calico printing; *e.g.*, the sons of manufacturers, calico printers, managers, master dyers, &c. Honours Course (*b*) is more largely concerned with the study of colour manufacture, and is designed for the training of factory and research chemists required by works which are engaged in the preparation of dyestuffs.

Textile Industries Department.

Professor—Aldred F. Barker, M.Sc.

Lecturer in Textile Industries—H. Priestman.

Lecturer in Yarn Manufacture—T. Hollis.

Lecturer in Textile Chemistry—

Engaged on Special Research—S. A. Shorter, D.Sc.

Assistant Lecturers—A. Yewdall, W. Law, F. Pickles.

The courses of instruction extend over three or four years according to the Degree or Diploma Course selected. Shortened courses are arranged for special sections of the work. The practical equipment is designed to enable workers in the department to pass wool through every process from the Raw Material to the Finished Fabric. The Research Laboratories are equipped for the Scientific Investigation of the fundamental principles underlying all the processes involved in Wool Manufacture. Clothworkers' Scholarships are at the disposal of the University, and it is very probable that under the newly developed West Riding of Yorkshire Scheme valuable Travelling Scholarships will be available for Senior Textile Students.

Leather Industries Department.

Professor—Douglas McCandlish, M.Sc.

Assistant Lecturers and Demonstrators—W. R. Atkin, M.Sc.; F. C. Thompson, M.Sc.

Demonstrator—D. Burton, M.Sc.

The full Courses, which extend over a period of either two or three years, are suitable to all who intend to become Technical Chemists in the Leather Industry, or managers of important works, and are recommended to sons of tanners. The Courses include instruction in chemistry, a modern language, leather manufacture, and practical work in the Leather Industries Laboratory and Dye-house. In 1914 the capacity of the University to undertake research in this branch of Applied Science was greatly extended by the establishment, in a new building adjoining the Leather Department, of the Procter International Research Laboratory, erected by the leather industries of the world in recognition of the work of Henry Richardson Procter, the first Professor of Leather Industries in the University.

Agricultural Department.

Professor—R. S. Seton, B.Sc.

Professor of Agricultural Chemistry—

Assistant Lecturers in Agricultural Chemistry—W. Godden, B.Sc., A.R.C.S., F.I.C.; N. M. Comber, B.Sc., A.R.C.S.; J. A. Hanley, Ph.D., A.R.C.S.

The full Course occupies three years, and includes instruction in chemistry, physics, mathematics, geology,

botany, forestry, engineering and surveying, and the principles of agriculture, as well as practical work in the various laboratories and out-door agriculture at the University Farm.

Department of Coal-gas and Fuel Industries with Metallurgy.

Livesey Professor—J. W. Cobb, C.B.E., F.I.C.

Lecturer in Gas Chemistry—H. J. Hodsman, M.Sc.

Research Assistant and Assistant Lecturer in Refractory Materials—H. S. Houldsworth, M.Sc., Leeds.

Research Chemists—J. W. Wood, M.Sc.Tech., Manchester; A. Parker, D.Sc.

Research Assistants—F. S. Townend, B.Sc.; Horace Kerr.

The Courses extend over two, three or four years, and are suitable for those who are preparing for posts either as Gas Engineers or in Fuel and Metallurgical industries.

The Courses in Gas Engineering and the Technology of Fuel will chiefly deal with the manufacture and distribution of coal-gas and gas-lighting problems, by-products coking processes, and the production and application of gaseous fuels for heating and power purposes.

The Metallurgical Courses, besides dealing with general processes for the concentration and extraction of ores, will be chiefly directed to problems underlying blast furnace and open-hearth steel practice, and to the micro-structure, physical properties, and heat treatment of steel and other industrial alloys.

Special attention is paid to the study of Refractory Materials.

Research Students are admitted to the University Laboratories on reduced terms.

Several valuable Fellowships and Scholarships are at the disposal of the University, including a Fellowship of £100 offered by the Institution of Gas Engineers, and the Salt, Akroyd, Brown, Baines, Emsley, Craven, and Clothworkers' Scholarships, and one of the 1851 Exhibition Scholarships. The Leeds City Council's and the North, East, and West Ridings County Council's Scholarships are tenable at the University of Leeds.

UNIVERSITY OF LIVERPOOL.

[Up to the time of going to press we had not received the necessary particulars from this University. To ensure accuracy it would be advisable, therefore, to communicate direct with the Registrar].

The Session commences early in October.

The Classes meet the requirements of candidates for the Ordinary B.Sc. Degree, for Chemistry Honours, or for the M.Sc. or D.Sc. Degree in the University of Liverpool; for Degrees in Medicine of Liverpool; for the Pharmaceutical, Veterinary, Dental, and Public Health Diplomas; and for those studying Chemistry as a preparation for professional, technical, or commercial life. The Classes qualify for the Associateship of the Institute of Chemistry and other Examination Boards.

Lecture Courses.

A. General Introductory Course, including the principles of Organic and Physical Chemistry. Three Terms. Fee, £4.

Engineer's Course of Lectures with Practical Class, Two Terms. Fee, including Practical class, £6.

Course A.—General Elementary Chemistry, £4.

Course B.—Inorganic Chemistry. Fee, £3.

Course C.—Inorganic Chemistry (Honours Course). Fee, £4.

Course D.—Organic Chemistry. Fee, £3.

Course E.—Organic (Honours). Fee, £4.

Course F.—Physical Chemistry. Fee, £3.

Course G.—Honours Physical Chemistry. Fee, £4.

Course H.—Applied Inorganic Chemistry, £2 10s.

Course J.—Metallurgy. Fee, £2 10s.

Course K.—Applied Organic Chemistry. Fee, £2 10s.

Course L.—Electro-chemistry. Fee, £2 10s.

Also Pass and Honours Courses in Bio-chemistry.

Research students carrying out research work pay a fee of £3 per annum.

The Inorganic and Organic Chemical Laboratories provide accommodation for every kind of work and research in inorganic and organic chemistry and in metallurgy. There is also a laboratory devoted to spectroscopic work and research.

The Muspratt Laboratories of Physical Chemistry and Electro-chemistry adjoin the main chemistry buildings, and, owing to their full equipment, offer every opportunity for all manner of work and research in these subjects.

The Bio-chemical Laboratory is also separately housed, and provides facilities for work and research.

Students desirous of gaining a thorough theoretical and practical acquaintance with Technical Chemistry, or who intend to adopt Chemical work as a profession, must devote three or four years to special study, for which a full curriculum is provided. Fees:—

Per Week	One Term, Three Months.	Three Terms One Session
One day	£4	£7
Two days	5 10s.	10
Three days	7	13
Whole week	10 10s.	21

D.P.H. Course (see special syllabus).

Course for Dental Degree and Diploma (see special syllabus).

Technological Curriculum.

The curriculum extends over three or four years.

The Final Examination for the Associateship of the Institute of Chemistry may be taken after the third year. Those students who have taken the Ordinary Degree of B.Sc. may pass the M.Sc. Exam. in any subsequent year.

The Sheridan Muspratt Scholarship of £50 per annum, tenable for two years, will be competed for in December, 1919, on an Examination in subjects which are included in the first two and a half years of the above curriculum. Candidates should send in their names to the Registrar not later than November 15. The Campbell Brown and Sir John Willox Scholarships, on similar lines, are open for competition. Other Scholarships, Entrance Scholarships, and Free Studentships are also available to Students. Regulations as to these may be obtained from the Registrar.

ARMSTRONG COLLEGE, NEWCASTLE-ON-TYNE.

(IN THE UNIVERSITY OF DURHAM).

Professor of Chemistry—P. Phillips Bedson, M.A., D.Sc., F.I.C., F.C.S., J.P.

Professor of Organic Chemistry—Samuel Smiles, O.B.E., D.Sc., F.R.S.

Readers in Chemistry—F. C. Garrett, D.Sc., F.C.S., and J. A. Smythe, D.Sc., Ph.D., F.C.S.

Assistant Lecturers and Demonstrators—Miss C. B. Schofield, M.Sc.; W. M. Madgin, M.Sc.; P. L. Robinson, M.Sc.

Lecturer in Agricultural Chemistry—S. Hoare Collins, M.Sc., F.I.C., F.C.S.

Assistant Lecturer in Agricultural Chemistry—A. A. Hall, M.Sc., Ph.D.

First Year Courses.—Division I.—This Course of Lectures will extend over the three terms of the Session, and is intended to serve as an introduction to the Science. The Lectures will be of an elementary character, and whilst framed to meet the requirements of First Year Students will also be serviceable to such as intend pursuing Chemistry in its various applications in the arts and manufactures, as, for instance, Brewing, Metallurgy, the Manufacture of Soda, Soap, Glass, &c. The subjects treated will include an exposition of the Principles of Chemistry, and a description of the preparation and properties of the chief Elementary Substances, both metallic and non-metallic, and their more important native and artificial compounds. The class will meet on Mondays, Wednesdays, and Fridays, at 11 a.m., and will

commence on Wednesday, October 3rd. Fee, £3 10s. for the Session.

Division II. Similar to Division I., but modified to meet requirements of Students for Degrees in Engineering and Mining. Mondays 12 to 1, Tuesdays and Thursdays 10 to 11. Fee, £3 10s. for Session.

Second and Third Year Courses.—These lectures are designed to form a part of the course of instruction in Chemistry, and to prepare students for the examinations in Chemistry for the degree of Bachelor of Science, Pass and Honours.

(*a*) Inorganic Chemistry.—Advanced Course, Tuesdays and Thursdays at 11 a.m. Fees, Lectures, £3 10s. per session, and £1 10s. per term.

(*b*) Organic Chemistry.—Aliphatic and Aromatic Compounds, Tuesdays and Thursdays at 10 a.m. Fees, Lectures, £3 10s. per session ; £1 10s. per term.

(*c*) Organic Chemistry.—Advanced Course, Tuesdays and Thursdays at 12 noon for part of the session. Fees, Lectures, £3 10s. per session ; £1 10s. per term.

(*d*) History of Chemistry and Chemical Philosophy.—Saturdays at 10 a.m. Fees, Lectures, £3 10s. per session ; £1 10s. per term.

(*e*) Physical Chemistry.—Tuesdays and Thursdays at 12 noon for part of the session. Fees, Lectures, £3 10s. per session ; £1 10s. per term.

(*f*) Analytical Chemistry. — Fridays at 9.15 a.m. Fee, £1.

(*g*) The Rarer Elements and the Periodic Law.—Times to be arranged. Fees, Lectures, £3 10s. per session ; £1 10s. per term.

Students taking Chemistry for Pass Degree will attend in their second year the course *a* and *f*, and in their third year the courses *b* and *d*, in addition to the necessary Laboratory practice.

Students taking Chemistry for Honours Degree will attend in their second year the courses *a*, *b*, and *f*, and in their third year the courses, *c*, *d*, *e*, and *g*, in addition to the necessary Laboratory practice.

A Lecture Course in Analytical Chemistry will be given on Fridays, at 9.15 a.m. Fee for the course, £1.

Metallurgy and Assaying.—Lecturer, Prof. Louis, M.A., D.Sc., F.I.C., F.G.S.; Demonstrator, H. Dean, M.Sc., A.R.C.M. A Metallurgical Laboratory is provided, in which instruction is given in the ordinary processes of Dry Assaying, and in the preparation and analysis of Alloys, &c. Fees as for Chemical Laboratory.

Agricultural Chemistry.—The instruction in this branch of Chemistry will consist of a series of Lectures and of special practical work in the Chemical Laboratory. Students will be expected to have a knowledge of Elementary Chemistry, such as may be obtained by attending the General Course.

The Lecture Course in Agricultural Chemistry is arranged for two days a week throughout the Session. Fee, £3 10s.

Practical Chemistry.—The Laboratory is open from 10 a.m. to 1 p.m., and from 2 to 5 p.m., except on Saturdays, when it closes at 1 p.m. *Laboratory Fees.*—Students working six days per week £5 10s. per term, £15 per session ; one day per week, £2 per term, £5 per session.

Courses of Study.—Students will be divided into two classes :—(1) Regular, or Matriculated Students, who are also Members of the University of Durham ; and (2) Non-Matriculated Students. Regular Students will be required to follow such a course of study in the subjects professed in the College as will enable them to pass the Examinations for the degree of Bachelor in Science of the University of Durham. Non-Matriculated Students will attend such classes as they may select. Every candidate for admission as a matriculated student must have passed the University Matriculation Examination.

Matriculation Examination.—In order to enter on a course of study for a Degree a student must have previously satisfied the Examiners in the following subjects :—(1) English, (2) English History, (3) Mathematics, (4) three of the following subjects, of which one must be a language:—(*a*) Religious Knowledge, (*b*) Latin, (*c*) Greek, (*d*) Ancient History, (*e*) French, (*f*) German, (*g*) some other language to be approved, (*h*) Experimental Science or Physics or Chemistry, (*i*) Botany or Zoology, (*j*) Mechanics, (*k*) Extra Mathematics, (*l*) Geography.

(i.). Candidates for degrees in Arts, who do not offer Latin in their Matriculation Examination or in the equivalent accepted as exempting therefrom, will be required to pass in Latin at a subsequent examination before entering upon the Arts course.

(ii.). Candidates for degrees in Commerce, who do not offer a Modern Foreign Language in their Matriculation Examination, or in the equivalent as exempting therefrom, will be required to pass in a Modern Foreign Language at a subsequent examination before entering upon the Commerce course.

(iii.). Candidates for degrees in Engineering (Civil, Mechanical, and Electrical) and in Naval Architecture will be required to take the following subjects from the list :—(1) English ; (2) English History, including Geography ; (3) one of the four languages—Latin, Greek, French, German ; (4) Extra Mathematics ; (5) and (6) either Experimental Science and Mechanics, or any two of the following subjects—Chemistry, Physics, Mechanics.

(iv.). Foreign Students may be exempted from the Matriculation Examination on report from the Board of Professors of Armstrong College, that they have received such an education in their own country as will enable them to profit by University study, and that they have sufficient knowledge of English to enable them to follow the courses of instruction they are entering for.

For detailed Syllabuses and complete Regulations the College Prospectus should be consulted.

Bachelorship in Science.—The degree of Bachelor of Science is conferred in Pass and Honours in Pure and Applied Science. For details of curricula, &c., the College Prospectus should be consulted.

Exhibitions.—Three Exhibitions of the value of £15 will be awarded in September to Candidates desirous of attending the first year course of study in the College.

The examination will be held at the College, and will commence on Thursday, Oct. 2nd, 1919. Candidates should send in their names to the Registrar on or before September 10th.

Several valuable Scholarships are available for students, including the Johnston Chemical Scholarship of the value of £60 for one year, which is open to Bachelors of Science of any British University ; the examination for this Scholarship will be held during the week commencing October 6th. Candidates should send in their names to the Registrar on or before September 27th.

THE UNIVERSITY OF MANCHESTER.

Professor of Chemistry and Director of the Chemical Laboratories—Harold B. Dixon, C.B.E., M.A., M.Sc., Ph.D., F.R.S.

Professor of Organic Chemistry — Arthur Lapworth, D.Sc., F.R.S.

Reader in Stoichiometric Chemistry—F. P. Burt, D.Sc.

Senior Lecturers—Norman Smith, D.Sc. ; J. E. Myers, D.Sc. ; W. J. Jones, M.Sc.

Lecturers—Colin Campbell, M.Sc.; D. H. Bangham, B.A.; H. Stephen, M.Sc.

Assistant Lecturers—W. K. Slater, M.Sc.; F. Fairbrother, M.Sc.

Professor of Metallurgy—C. A. Edwards, D.Sc.

Assistant Lecturer in Metallurgy—

Lecturer in Electro-Chemistry—J. N. Pring, D.Sc.

Chemistry Lecture Courses.

General Chemistry Course.—Tuesdays, Thursdays, and Saturdays, at 9.30, during the two Winter Terms.

This course is intended for Students commencing the study of chemistry.

Introduction to Organic Chemistry.—Mondays, Wednesdays, and Fridays, at 11.30, during the Summer Term. This course is designed to meet the requirements of Students preparing for the Intermediate B Sc. Examination.

Biochemistry, Theoretical and Practical—Tuesdays and Thursdays during the Summer Term. This Course prepares for Part III. of the first M.B. Examination.

First Year Honours Course.—Mondays, Wednesdays, and Fridays, 11.30, during the two Winter Terms. The Non-Metals treated historically.

Second Year Honours Course.—Mondays, Wednesdays, and Fridays, at 2, during the two Winter Terms. The Metals, and Introduction to Physical Chemistry.

Third Year Honours Course.—Theoretical and Physical Chemistry.

Organic Chemistry (General).—Mondays, Wednesdays, and Fridays, at 9.30, during the two Winter Terms.

Organic Chemistry (Advanced).—Tuesdays and Thursdays, at 9.30, during the two Winter Terms.

History of Chemistry.—Short Courses during the two Winter Terms.

Chemistry of Colouring Matters — Theoretical and Practical Course during the Winter Terms.

Metallurgy.—Introductory Course, followed by either—(A) Lead, Copper, Bismuth, Antimony, Zinc, and Tin; or (B) Iron and Steel. Course A, two Lectures per week during the first half of the Session; Course B, one Lecture per week during the Session.

Electro-chemistry.—General Theoretical Course: One hour per week during the Michaelmas and Lent Terms. Applied Course: One hour per week during Michaelmas and Summer Terms.

B.Sc., with Honours in Chemistry.—The course extends over three years, and comprises systematic instruction by means of lectures and practical work in the laboratories.

The Research Laboratories for Inorganic, Organic, and Physical Chemistry, and for Metallurgy, are open to graduates and other advanced students.

For further particulars of any of these courses apply to the Registrar, Edward Fiddes, M.A., or to the Director of the Laboratories.

UNIVERSITY COLLEGE, NOTTINGHAM.

Departments of Chemistry and Metallurgy.

Professor of Chemistry—F. Stanley Kipping, Ph.D., D.Sc., F.I.C., F.R.S.

Demonstrators of Chemistry—E. B. R. Prideaux, M.A., D.Sc.; H. Lambourne, B.A., B.Sc., F.I.C.; J. B. Firth, M.Sc., A.I.C.; W. H. Craven, B.Sc., A.I.C.

The Classes of the College are open to students of both sexes above sixteen years of age.

Lecture Courses.—The Chemistry Day Lectures extend over three years. In the first year a student attends a course on Inorganic Chemistry. In his second year he attends Lectures on both Inorganic and Organic Chemistry. In his third year he attends courses on Advanced Organic Chemistry, Physical Chemistry, and Advanced Inorganic Chemistry.

Demonstrations and Lectures on Analytical Chemistry are given, and Chemical Calculation and Tutorial classes are also held. Various short courses of lectures on special subjects are delivered during the Session.

Students may qualify themselves by attendance at these lectures and classes for the Examinations of the Universities of London, Cambridge, or Oxford, and for the Medical Examinations of the Royal College of Surgeons and of the Universities of Cambridge and Edinburgh; they may also obtain instruction in Chemistry for technical or other purposes, and can enter for a full Chemical Engineering Curriculum. Special attention is given to the requirements of candidates for the Associateship of the Institute of Chemistry.

Practical Chemistry and Metallurgy.—The Chemical and Metallurgical laboratories are open every day from 9 to 5, except on Saturday, when the hours are from 9 to 1; also on Tuesday and Thursday evenings from 7 to 9. Each Student works independently of other Students at a course recommended by the Professor. Instruction is given in general Chemical Manipulation, in Qualitative and Quantitative Analysis, and in the methods of Original Chemical Investigation and Research; Students are also enabled to work out the applications of Chemistry to Pharmacy, Metallurgy, Dyeing, Brewing, Iron and Steel, and other Manufacturing Processes.

Research Work.—Students or others wishing to undertake research work in Pure or Applied Chemistry will be afforded every facility for doing so and may be admitted at reduced fees. The Laboratories are fully equipped with apparatus and chemicals necessary for such work.

Courses of Technical Chemistry Lectures are also given from time to time on Dyeing and Bleaching, Brewing, Plumbing, Gas Manufacture, and other processes of applied Chemistry.

Complete day and evening courses are also held for students preparing for the examinations of the Pharmaceutical Society and Apothecaries' Hall.

The composition fee for full time in the Chemistry Department (lectures and laboratory) is £7 7s. per term, or £21 for the Session if paid in advance, and this fee covers all necessary apparatus and chemicals.

A composition fee of £7 7s. per term, or £21 for the Session if paid in advance, is also charged for various complete courses, such as those required for the Institute of Chemistry, and for the degree examinations of London University.

Evening Classes.—Evening Lectures and Laboratory instruction will be given in Pure and Applied Chemistry, and the laboratories are open for practical work on Tuesday and Thursday evenings from 7 to 9. Fee for each Lecture Course, 12s. 6d.; for each Laboratory Course, 12s. 6d.

Full information concerning all College Classes is given in the College Prospectus, free from the Registrar.

THE UNIVERSITY OF SHEFFIELD.

Professor of Chemistry—W. P. Wynne, D.Sc., F.R.S.

Lecturer on Organic Chemistry—J. Kenner, D.Sc., Ph.D.

Lecturer on Physical Chemistry—A. S. Russell, M.C., D.Sc.

Assistant Lecturers—Emily G. Turner, M.Sc.; Dorothy M. Bennett, M.Sc.; T. B. Smith, B.Sc.

The Session will commence October 1st.

Matriculation Course. — Tuesday and Friday at 9 30, Wednesday at 11.30 during Michaelmas and Lent terms, and three hours per week Laboratory work.

Candidates for the Intermediate Examination are required to satisfy the Examiners in three of the following subjects:—Pure Mathematics, Applied Mathematics, Physics, Chemistry, Zoology, Botany, and Geology. And those for the Final Examination in either two principal subjects, or in one principal and two subsidiary subjects, selected from the following list:—Principal subjects (studied for two Sessions), Pure and Applied Mathematics, Physics, Chemistry, Zoology, Botany, Physiology, Geology, Geography; subsidiary subjects (studied for one Session) Pure Mathematics, Zoology, Botany, Geology, Education, Geography.

Intermediate Course in Chemistry for B.Sc. or M.B., Ch.B. or B.Met., or B.Sc.Tech. or B.Eng. (Mining)—Monday, Wednesday, Thursday, and Saturday, at 9.30 a.m.; and six hours per week Laboratory work during first year.

B Sc. Course in Chemistry.—Tuesday, Thursday, and Friday at 11.30 a.m. during second year; Tuesday, Thursday, and Friday at 9.30 a.m. during the third year; and twelve hours per week Laboratory work during second and third years.

B.Sc. with Honours.—Honours Students in Chemistry are expected to reach the standard for a pass in Chemistry for the ordinary degree by the end of the second year. During the second or third year they devote one day a week to lectures and practical work in a subsidiary subject—

Mathematics, Physics, or Metallurgy—selected for the degree. The third year is devoted to the advanced study of Chemistry. At least four days a week during the second and third years are spent in the laboratory.

The compsition fee for the courses leading to the B.Sc. degree is £75, payable in three annual instalments of £25.

M.Sc.—This degree may be conferred upon a Bachelor of Science with Honours who has obtained either a first-class or a second-class in his Honours examination and is of one year's standing from the date of his graduation as a Bachelor of Science, or upon a Bachelor of Science who has either passed an examination in an Honours School subsequent to graduation, or has for at least one year after graduation done research work at the University, and has presented a *thesis*, approved by the Faculty of Pure Science, upon the research work done during that period.

Ph.D.—This degree may be conferred on registered graduates of the University of Sheffield, or of any other approved University, who have pursued a course of advanced study and research in the University for a period of not less than two academic years, have presented a thesis embodying the result of the research, and have been examined orally in matters relevant to the subject of the thesis.

D.Sc.—The degree of Doctor of Science may be conferred upon any Master of Science of not less than five year's standing from the date of his admission to the degree of Bachelor, provided that he has published, in recognised journals or transactions, a research or researches of special merit and approved by the Faculty of Pure Science as qualifying him for the degree.

Faculty of Metallurgy.

Dean and Professor—J. O. Arnold, D.Met., F.R.S.

Senior Lecturers—F. K. Knowles, B.Met.; F. Ibbotson, B.Met., B.Sc., F.I.C., F.R.C.Sci.

Lecturers—J. H. Wreaks, B.Met.; F. C. Thompson, D.Met., B.Sc.

Demonstrators—L. Johnson, B.Met.; H. Waterhouse, B.Met.

Lecturer in Non-ferrous Metallurgy—G. B. Brook.

Demonstrator—F. Orme, M.Met.

Lecturer in Electro-metallurgy—(Vacant).

This Faculty has been equipped to meet the require ments of the local industries. The Laboratories are fitted with the most modern apparatus for metallurgical analysis, more especially with appliances for the rapid and accurate chemical examination of iron and steel, fuel, and refractory materials. It also contains a complete pyrometric installation, and a laboratory for the study of the micrographic analysis of metals fully equipped with specially designed microscopes by Ross, polishing tables, etching appliances, incandescent light for evening work, &c. The Faculty is now most complete for teaching the practical manufacture, the chemical constitution, and the physical properties of steel. Special attention is given to the determination of the microscopic constituents of steel. Although the chief industry of the district occupies the central position in the course of instruction, general metallurgy is dealt with in the Non-ferrous Department described below. Students are thus enabled to select and at once enter upon a course of scientific metallurgical training of immediate practical utility. They may take up and work through any portions of the course, but certificates are granted only to those who follow the prescribed courses and pass the necessary examinations. Lectures on Iron and Steel Manufacture, on Fuel and Refractory Materials, and Metallurgical Geology. Practical Metallurgy :—Laboratory, Furnaces, Foundry, and Testing Machine Course; Practical Course of Metallurgy other than Iron and Steel; Practical Fuel Course for Students in Collieries or Gas Works.

A steel works has been erected in connection with the Sheffield University at a cost of about £15,000, with a most varied and complete plant. The most recent addition to the steel works plant is a 3 cwt. Kjellin induction furnace worked by a 120 H.P. Motor-generator set with two-phase current. The Faculty of Metallurgy of Sheffield University is "in association" with the Royal School of Mines for teaching the advanced metallurgy of Iron and Steel.

There has been recently added to the curriculum Day and Evening courses in Electro-metallurgy and Non-ferrous Metallurgy. The Electro-metallurgical Laboratory is completely equipped for the practical study of every branch of the art of the Electro-deposition of metals, special attention having, however, been paid—in the selection and arrangement of plant and apparatus—to the specific requirements of the Sheffield trades. The plant and machinery is thoroughly up-to date in character. Working accommodation is provided for 30 students at one time. The course extends over three university years.

The Non-ferrous Department has been established to meet the needs of the lighter Sheffield trades of Silver and Electro-plate, Brass, and allied industries. It is completely equipped for dealing with every phase of the work from the raw material. The melting shop is fitted with furnaces capable of dealing with casts up to 70 lbs. weight, so that commercial practice can be followed. Two large laboratories, the one with 32 places for preparatory students, the other with accommodation for 40 advanced students, provide the means for the Chemical examination of the alloys prepared. A Staff and Post-graduate research laboratory completes the provision for the chemical side of the work. The Micrographic Laboratory is equipped with a complete Zeiss Photo-micrographic camera, direct driven polishing blocks, and Ross microscopes. The recalescence laboratory for the estimation of temperatures during melting, annealing, or other heat treatment has a complete pyrometric installation. An Arnold and Colver-Glauert Pyrometer permits of readings every 1° C. up to 1300° C. Facilities are provided for observing the thermal changes *in vacuo*. The Chronographic recorder is served by electric or coke furnaces, and the installation may be regarded as the most complete of its kind.

Degrees are awarded to successful students in Steel Metallurgy, and Associateships in both Steel and Non-ferrous Metallurgy.

UNIVERSITY COLLEGE, READING.

Professor of Chemistry—H. Bassett, D.Sc., Ph D., D. ès Sc., F.I.C.

Lecturer—J. W. Dodgson, B.Sc., A.I.C.

Assistant Lecturer—A. Fairbourne, M.Sc., A.I.C.

Professor of Agricultural Chemistry—(Vacant).

Research Chemist in Dairying—J. Golding, F.I.C.

Lecturer in Agricultural Chemistry—J. A. Murray, B.Sc.

The lectures and laboratory work are so arranged as to be suitable for students preparing for the London B.Sc. (Pass or Honours), or for the College or other Diplomas in Agriculture, Horticulture, or Dairying. There is a general course of Intermediate standard, also another suitable for first year students of Agriculture and Horticulture. In their second and third years Science students attend special lectures in Inorganic, Organic, and Physical Chemistry, while Agricultural students take special courses under the Professor of Agricultural Chemistry. The laboratories are well equipped for all branches of practical work.

Halls of Residence—(Men) Wantage Hall, St. Patrick's Hall; (Women) St. Andrew's Hall, Wessex Hall, St. George's Hall.

Full details of fees, scholarships, &c., can be obtained from the Registrar.

UNIVERSITY COLLEGE, DUNDEE.

University of St. Andrews.

Professor of Chemistry—Alex. McKenzie, M.A., D.Sc., Ph.D., F.R.S., F.I.C.

Lecturer—(Vacant).

University Assistants—Miss N. Walker, M.A., B.Sc.; Miss. I. A. Smith, M.A., B.Sc.

Lecture Assistant and Lab. Steward—J. Foggie.

The Session consists of three Terms:—The Martinmas Term begins early in October and ends before Christmas; the Candlemas Term begins early in January and ends about the middle of March; the Whitsunday Term begins in the middle of April and ends at the end of June.

Three Courses of Lectures are given, each extending through all three terms. The General Course, meeting four or five days a week (including Tutorial Meetings), is intended for beginners, and qualifies for Graduation Examinations in Arts (M.A. General), Science (First B.Sc.), and Medicine (First M.B., Ch.B.).

The Special and Honours Courses, each meeting twice or thrice weekly, qualify for Degree Examinations in Arts (Special and Honours, respectively), and in Science (Final B.Sc. on Intermediate and Higher Standard, respectively).

All three are General Courses, including Inorganic, Physical, and Organic Chemistry.

The Laboratories are well equipped, and instruction is provided for students in Arts, Science (Pure and Applied), Medicine (including Public Health); provision is also made for students desiring to undertake Research.

UNIVERSITY OF ABERDEEN.

CHEMISTRY.

Professor—Alexander Findlay, M.A., D.Sc., Ph.D., F.I.C.

Lecturers—Francis W. Gray, M.A., D.Sc.; Joseph Knox, D.Sc.

Assistants—Marion B. Richards, D.Sc.; Beatrice W. Simpson, B.Sc. (Two vacancies).

I. *General Lecture Course, Systematic Chemistry.*—(Daily during the Winter Session at 3 p.m.). These lectures treat of:—(1) The Laws of Chemical Combination and the General Principles of Chemistry, including Chemical Calculations; (2) the Elements classified according to the Periodic Law; (3) Organic Chemistry; (4) Applications of Chemistry to the Arts and Manufactures. Two written Class Examinations are held. A Tutorial Class (without fee) is held in connection with the General Lecture Course. Fees, for first attendance, £4 4s.; for subsequent attendance, £3 3s.

II. *Elementary Practical Course for all Students.*—(Winter Session). Demonstration on Monday at 12 noon. For practical work the class will be divided into two or more groups, meeting one day a week, from 10 a.m. to 1 p.m. This course is devoted to practice in Chemical Methods and in Elementary Qualitative Analysis. The instruction is under the direction of the Professor of Chemistry and the Staff. One practical examination is held at the end of the course, namely, the Degree Examination, but it must be attended by all, those not sitting the Degree Examination taking it as a Class Examination. Students in all faculties are required to pass this practical examination as well as the written examination, as part of the requirements for the Degree. The practical course should be taken, whenever possible, concurrently with the Systematic course. Fee, £3 3s. This fee includes the necessary apparatus and appliances, with certain exceptions such as platinum-foil and wire.

Scheme of Lecture Courses for the B.Sc. Degree in Chemistry (subsequent to Courses I. and II.).

III. Lecture courses in Organic, Inorganic, and Physical Chemistry are given by the Professor and Lecturers as the exigencies of the times allow. The following arrangement is given as liable to alteration:—

(*a*) Introductory Course of 30 lectures, mainly on some modern lines of advance in Physical Chemistry, by the Professor, three days weekly at noon in the Summer Session. Fee, £2 2s.

(*b*) A combined course of Physical and Inorganic Chemistry of about 80 lectures two days weekly at noon in Summer Session, three days weekly in Winter Session, at noon in the First and at 3 p.m. in the Second Term. Fee, £3 3s.

(*c*) A course of 50 lectures in Organic Chemistry in Winter Session, three days weekly at noon in the First and two days weekly at 3 p.m. in the Seoond Term. Fee, £3 3s.

IV. *Chemical Laboratory.*—The Laboratory is open daily from 9 a.m. to 5 p.m. Each student on entering is allowed to arrange his hours of work so as to suit his own convenience, but must adhere to these hours when once fixed. The aim of the Laboratory Courses is to train the student in the practical methods of the science, so as to enable him to conduct chemical analysis and original research, and to apply chemistry to the arts and manufactures. Weekly Demonstrations, attendance on which is compulsory, are held in connection with the Laboratory Courses.

Research.—The Laboratory is open for original work during both the Summer and Winter Sessions.

Students in Chemistry are eligible for the Robbie Scholarship, the Yuill Scholarship, 1851 Exhibition Scholarship, Fullerton Scholarship, and Carnegie Research Scholarships. (For information see Calendar).

UNIVERSITY OF ABERDEEN AND ABERDEEN AND NORTH OF SCOTLAND COLLEGE OF AGRICULTURE.

Agricultural Chemistry and Forest Chemistry.

Professor—James Hendrick, B.Sc., F.I.C.

Assistant—Alfred Hill, B.Sc., B.Sc. (Agr.).

I. A Preparatory Course in General Chemistry including Organic Chemistry is given for those who are unable to take the full University Course. The course in Inorganic Chemistry consists of about sixty Lectures with Practical Work (seven hours weekly) during the Winter Session. The course deals with the general principles of Chemistry, and with those parts of Inorganic Chemistry which are of more immediate concern to students of Agricultural Chemistry. The Practical Work goes along with and illustrates the Lectures. Fee, £4 4s.

The course in Organic Chemistry consists of about thirty Lectures, and about thirty hours practical work, and is given during the Summer Session. It deals especially with those parts of the subject which are directly related to Agricultural Chemistry. Fee, £2 2s.

II. *Agricultural Chemistry* (*General Course*).—This class meets daily during the Winter Session, and three times a week during the Summer Session, and includes both Lectures and Laboratory Work. The Lectures deal with the Chemistry of the Atmosphere, the Soil, Manures, Foods, Preservatives, Insecticides &c. The Physiological Chemistry of Plants and Animals, the Composition and Manurial Requirements of Crops, and Dairy Chemistry are also treated of. The Laboratory Work is primarily intended to accompany and illustrate the Lectures. Exercises dealing with the properties and composition of Soils, Manures, Feeding-stuffs and Waters, and with the impurities and adulterations of these, occupy much of the time given to Practical Work. The fee for the whole Course (Lectures and Practical Work) is £4 4s.

III. *Forest Chemistry* (*General Course*).—Students in Forestry take the greater part of the General Lecture Course in Agricultural Chemistry, with special lectures on the Chemistry of Timber and Forest Products. The early part of the Laboratory Work is the same as in the case of Agricultural Students, but the latter part is occupied with special exercises on Forest Products. Fee, £4 4s.

IV. *Laboratory.*—A Summer Course in Practical Chemistry is given to prepare students who have not previously done sufficient laboratory work for the course in Agricultural Chemistry or Forest Chemistry. Fee, £2 2s.

V. The Laboratory is open daily from 9 a.m. to 5 p.m. for students who wish to study the principles and practice

of Agricultural Chemistry or Forest Chemistry, or to undertake research in these subjects.

The fees mentioned above are subject to reduction in the case of students from counties and burghs within the College area, and there are a number of bursaries, some granted by local authorities and some by the University, open to students.

UNIVERSITY OF EDINBURGH.

Department of Chemistry.

Professors—James Walker, LL.D., D.Sc., Ph.D., F.R.S.; George Barger, M.A., D.Sc., F.R.S.

Lecturers—L. Dobbin, Ph.D.; J. E. Mackenzie, Ph.D., D.Sc.; S. A. Kay, D.Sc.; H. G. Rule, D.Sc., Ph.D.; A. M. Williams, M.A., D Sc.; D. Balsillie, B.Sc.; J. D. M. Ross, M.A., B.Sc., M.B.E., and Demonstrators.

Lecturer on Technical Chemistry—A. C. Cumming, D.Sc., O.B.E.

The three working terms are each of ten weeks' duration, viz.:—Autumn term, October to December; Spring term, January to March; Summer term, April to June.

Lecture Courses.—During the Winter Session a General Course of Chemistry for medical students is given. The class meets daily; fee, £4 4s. The First Course for Arts and Science students meets three times a week throughout the year; fee, £4 4s. The Second Course is given on Organic, Advanced Inorganic, and Physical Chemistry. The class meets three times a week throughout the year; fee, £4 4s. Tutorial Classes are held in connection with the First and Second Courses. All Arts and Science Classes are open to Women Students.

In addition to the above, Advanced Lecture Courses are given on particular branches of Physical, Organic, and Inorganic Chemistry.

N.B.—After Oct. 1, 1921, students will only be permitted to attend the Elementary Classes in Chemistry after passing an Admission Examination in the rudiments of Chemistry or an examination held by the Senators to be equivalent thereto.

Laboratories.—Practical classes for Medical Students meet during the Winter Session and in the Summer Session. (Fee, £3 3s.): The Elementary Laboratory course for Arts and Science students is held for four hours per week during the year. Fee, £4 4s. The advanced laboratories for Science and Arts Students engaged in analytical and advanced practical work are open daily from 9.30 till 4.30. Fees: Whole Day—Year, £16 16s.; one term, £6 6s. Half Day—Year, £8 8s.; one term £3 3s. Full Courses of instruction are given in Analytical, Practical Organic and Inorganic Chemistry (including Gas Analysis, Physico-chemical Measurements, and Assaying). Facilities are afforded to advanced students who desire to undertake chemical investigations.

Various prizes and scholarships are attached to the laboratory and general class.

Graduation.—Two Degrees in Pure Science are conferred, viz., Bachelor of Science (B.Sc.) and Doctor of Science (D.Sc.).

Candidates for Degrees in Science, if not graduates (by examination) in Arts in one of the Universities of the United Kingdom or in a Colonial or Foreign University recognised for the purpose by the University Court, must pass a preliminary examination in (1) English; (2) Latin, Greek, French, or German; (3) Mathematics; (4) One of the languages Latin, Greek, French, German, Italian, not already taken under (2), or Dynamics. In the case of a student whose native language is other than European, the Senatus may, at the Preliminary Examination, accept such language as a substitute for a modern European language. The Senatus may also in such a case accept as an alternative to Latin or Greek any other classical language, such as Sanscrit or Arabic.

The First B.Sc. Examination embraces Mathematics, or Biology (*i.e.*, Zoology and Botany), Natural Philosophy, and Chemistry. The Final B.Sc. Examination in Pure Science includes any three or more of the following subjects:—Mathematics, Natural Philosophy, Astronomy, Chemistry, Human Anatomy (including Anthropology), Physiology Geology (including Mineralogy), Zoology (including Comparative Anatomy), and Botany (including Vegetable Physiology). In the Final Examination two written papers are set in each subject professed, the second of a higher standard than the first. Candidates must pass the first section in all, and the second section in at least one, of the subjects professed; the same regulations apply also to the Practical and Oral Examinations. Chemistry in this examination embraces Inorganic Chemistry, Organic Chemistry, and Physical Chemistry. Practical Examination:—Complex Qualitative Analysis; Preparations; Gravimetric and Volumetric Analysis; Testing of Organic Substances. Each candidate taking the higher standard will also be examined on Ultimate Organic Analysis; Gas Analysis; and Physico-chemical Measurements.

A candidate for the D.Sc. Degree must submit a thesis on original work done by him. The Thesis must be approved before the candidate is allowed to proceed to Examination.

HERIOT-WATT COLLEGE, EDINBURGH.

Principal—A. P. Laurie, M.A., D.Sc., F.R.S E.

Staff.—Professor—A. Archibald Boon, D.Sc., B.A., F.I C., F.R.S.E.

Lecturers—J. Campbell Smith, B.Sc., A.I.C.; James Sandilands, A.I.C.; J. W. Ingham, B.Sc., A.I.C.; Arthur C. Francis, A.I.C.; Robert G. M. Dakers, Assoc.H.W.C. (Demonstrator); and other Demonstrators.

The curriculum of this College comprises both Day and Evening Classes, each department providing the higher general and technical education.

There is an extensive range of Chemistry Laboratories, embodying the most modern developments in laboratory design and equipment, and including a complete plant for the production of liquid air. The Chemistry Courses are designed to meet the requirements of Analytical and Technical Chemists. The College is a recognised training centre for the examinations of the Institute of Chemistry, and students can obtain the necessary instruction in General Chemistry, and also the specialised instruction required for the Final Examination for the Associateship of the Institute in the departments of Organic Chemistry, Metallurgy, Foods and Drugs, and Bio-chemistry.

The course for the Diploma of the College in Applied Chemistry has been laid down on the same general lines as that required for the examinations of the Institute of Chemistry, and includes a special study of branches of Chemistry relating to local industries.

The Chemistry Courses are recognised by the University of Edinburgh as qualifying courses for the B Sc. degree; and students are also prepared for the London B Sc. (pass and honours). Facilities are also offered to students desiring to prosecute Research.

There is also a Laboratory for the study of branches of knowledge in connection with the Fermentation Industries (Brewing, Distilling, &c.). In this laboratory provision is made for the teaching of Biology, and the microscopic examination of Foods and Drugs, in connection with the examinations of the Institute of Chemistry. Complete courses of instruction are also provided for Pharmaceutical students (both day and evening) preparing for the "Minor" and "Major" qualifications.

Day Classes open on October 14th, and the Evening Classes on October 2nd.

Matriculation Fee, 5s.; Composition Fees from £15 15s. to 21 guineas per annum. Full particulars are published in the Calendar of the College, issued early in September.

THE ROYAL TECHNICAL COLLEGE, GLASGOW.

Professor of Chemistry—(Vacant).

Professor of Technical Chemistry—T. Gray, D.Sc., Ph.D., F.I.C.

Lecturer on Dyeing—A. B. Steven, B.Sc.

Lecturer on Sugar Manufacture—T. H. P. Heriot, F.C.S.

Professor of Metallurgy—C. H. Desch, D.Sc., Ph.D., F.I.C.

Also, Professors and Lectures in the other leading branches of Pure and Applied Science and Technology.

Session opens September 24th, 1919.

The main object of this College is to afford a suit able education to those who wish to qualify themselves for following an industrial profession or trade. It was founded by an Order in Council, dated November 26th, 1886, according to a scheme framed by the Commissioners appointed under the provisions of the Educational Endowments (Scotland) Act, whereby Anderson's College (established 1796), the Young Chair of Technical Chemistry in connection with Anderson's College, the College of Science and Arts, Allan Glen's Institution, and the Atkinson Institution were placed under the management of one governing body.

The Diploma of the College is awarded to Day Students who have attended prescribed courses of instruction and passed the necessary examinations. The ordinary courses extend over three years, but arrangements are made for advanced students continuing their studies in special departments. The diploma course in Chemistry extends over four years.

Students who have matriculated at the University of Glasgow can qualify for the degree of B.Sc. in Applied Science by attendance on the Day Classes of the College.

Complete courses of instruction are provided in both Day and Evening Classes.

Prospectuses will be sent on application to the Director, Mr. H. F. Stockdale, LL.D.

UNIVERSITY OF ST. ANDREWS.

UNITED COLLEGE OF ST. SALVATOR AND ST. LEONARD

Professor of Chemistry—James C. Irvine, Ph.D., D.Sc., F.R.S.

Reader in Organic Chemistry — W. N. Haworth, D.Sc., Ph.D.

Assistants—Geo. Robertson, M.A.; B.Sc.; E. S. Steele, M.A., B.Sc.; Grace C. Leitch, M.A., B.Sc.; Helen Gilchrist, B Sc.

The Session begins on October 7th. A Competitive Examination, open to intending Students of Arts, Science, and Medicine, for about thirty-six Bursaries, ranging in value from £50 to £10 each per annum, is held annually in June. (For 1920 entries are due May 18th). One of these is open to Men or Women, and fifteen are restricted to Women, nine of the latter being intended for women who at the conclusion of their Arts or Science Course will proceed to Medicine. The remainder are open to men only.

A Hall of Residence is provided for Women Students.

Two Degrees in Science are conferred by the University of St. Andrews, viz., Bachelor of Science (B.Sc.) and Doctor of Science (D.Sc.), and Chemistry is also included in the curriculum for the M.A. Degree, and the M.B., Ch.B. Degrees. Arrangements have also been made for the institution of the Degree of Ph.D. for research work in Chemistry. The regulations will be found in the "University Calendar."

Lecture Courses.

Three distinct Courses of Lectures are given, each extending over the three terms of the academic year.

First Year's Course.—This Class meets at 11 o'clock on five days in the week. The introductory lectures treat of the Nature of Chemical Action, the Classification of Substances into Elements and Compounds, the Phenomena of Oxidation, and the Composition of Air and Water. The Laws of Chemical Combination and the Atomic Theory are next discussed, after which the more commonly occurring elements and inorganic compounds are described systematically. Elementary Organic Chemistry is also included in the Course.

Special attention is given to those parts of the science which are of general educational value, and as much of the theory of chemistry is introduced as is compatible with elementary treatment.

This course of instruction is intended to meet the requirements of the M.A., First Science, and M.B., Ch.B. Exams., so far as Theoretical Chemistry is concerned.

Second Year's Course.—The first part of the Course is devoted to Organic Chemistry, and the second part to General and Physical Chemistry, the instruction in general being such as is required for the Final Science Exam. on the Lower Standard and the Special Exam. for the M.A. Degree.

Third Year's Course.—Short courses of lectures on selected topics are given to Students preparing for the B.Sc. on the Higher Standard or the M.A. Degree with Honours.

Certificates are awarded on the results of examinations, and the "Forrester Prize" of about £10 is awarded to the best Student of the year.

Fee for the Session, for each Course, £4 4s.

Practical Chemistry.

The Laboratory is open daily from 9 a.m. to 4 p.m., except on Saturdays, when it is closed at 1 p.m. The work pursued in the Laboratory comprises:—(1) The performance of experiments illustrative of the Principles of Inorganic and Organic Chemistry; (2) Qualitative and Quantitative Analysis; (3) Practical Physical Chemistry. Each student pursues an independent course of study under the supervision of the Professor or Demonstrator, the nature of the work varying with the proficiency of the student and the particular object he may have in view. Suitable courses of instruction in Practical Chemistry are provided for candidates for the Exams. in Arts, Science, and Medicine.

The fee for the Ordinary Course of Practical Chemistry is £3 3s, and for the Advanced Course £10 10s.

Original Research.

A special Research Department has been instituted by the University, the laboratories of which are open to students who give proof of their capacity to conduct original investigation. Graduates of other Universities who spend two years in the laboratory as Research Students are eligible for the D.Sc. and Ph.D. degrees of the University, and special chemicals and apparatus are provided free of charge. Graduate workers can also qualify for the Berry, 1851 Exhibition, and Carnegie Research Scholarships or Fellowships.

Students may work either independently or in collaboration with the Professor, to whom all communications should be addressed.

QUEEN'S UNIVERSITY, BELFAST.

Professor of Chemistry—A. W. Stewart, M.A , D.Sc.,

Lecturer in Organic Chemistry—A. Killen Macbeth, M A., D.Sc., F I.C , &c.

I.—*Chemistry.*—The lectures are delivered at 12 o'clock on the first five days of each week, and terminate about the end of March. The course embraces the elements of Physical, Inorganic, and Organic Chemistry. Fee, £3 3s.

II.—*Advanced Chemistry.*—Inorganic and Organic. The lectures are given at such days and hours as suit the convenience of the class. Fee, £3 3s.

III.—*Practical Chemistry.*—In this course the Students are instructed in the general methods of Qualitative and Quantitative Analysis, Inorganic preparations, &c. The class is held on four days in the week during the second term for two hours each day. Fee, £4 4s.

IV.—*Practical Chemistry for Engineering Students.*—A special course is given during the first term. Fee, £3 3s.

V.—*Laboratory Pupils.*—The Chemical Laboratories are open from the second week in October to the beginning of July, on the first five days of the week, from 10 a.m.—5 p.m. (except during the vacations). Students are

admitted as working pupils on payment of a fee of £3 3s. per term. Facilities are provided for Students who wish to undertake research work.

Scholarships.—The following College Scholarships are awarded specially in connection with the schools of Chemistry and Physics:—Post Graduate Scholarships in Chemistry alone awarded annually of £50, and tenable for one year. Andrews Studentship in Chemistry and Physics, value about £73 annually, and tenable for two years. 1851 Exhibition Scholarships: One of these Scholarships has hitherto been placed at the disposal of the College every two years, of the annual value of £150, tenable for two or under special conditions for three years. and also one of the Industrial Bursaries.

UNIVERSITY COLLEGE, CORK.

A Constituent College of the National University of Ireland.

Professor—Augustus Edward Dixon, M.D.

Assistant Lecturer—John Taylor, D.Sc.

Demonstrators—R. T. J. Kennedy, B.Sc.; T. A. Conroy, M.A.

The College Session will commence in October, 1919, and end in June, 1920. All classes are open to male and to female students.

The following courses are provided:—

1. First Year Course for B.Sc.—General and Elementary Physical Chemistry, Inorganic Chemistry, Introductory Organic Chemistry, Practical Chemistry.
2. Second Year Course for B.Sc.—Advanced Inorganic Chemistry, Advanced Organic Chemistry, Practical Chemistry.
3. Third Year Course for B.Sc.—Physical Chemistry, Advanced Organic Chemistry, Practical Chemistry.
4. Courses in Systematic and in Practical Chemistry for students of Medicine proceeding to the Degrees of the University, or to the Examinations of the Medical Licensing Bodies of Dublin and of Edinburgh.
5. Courses in Systematic and in Practical Chemistry for Students of Engineering.
6. Laboratory Practical Course for the Diploma in Public Health.

Full particulars as to Lectures, Fees, Scholarships, Exhibitions, &c., are contained in the Regulations extracted from the College Calendar, which will be supplied on application to the Registrar.

NATIONAL UNIVERSITY OF IRELAND.

University College, Galway.

Professor—Thomas Dillon, M.A., D.Sc.

Demonstrator—Miss R. Clarke, B.A., D.Sc., F.I.C.

The Session commences in October and ends in June.

Faculty of Science.—1. *First Year's Courses.*—Laboratory: Inorganic preparations, simple quantitative and simple qualitative determinations. Lectures: A study of the chief non-metallic elements, their reactions and compounds, the molecular and atomic hypotheses, the leading metals, and an elementary consideration of the constitution and reactions of typical hormathic and cyclic compounds. 2. *Second Year's Courses.*—Laboratory: Organic preparations, complex qualitative and quantitative inorganic determinations. Lectures: Advanced inorganic and organic chemistry. 3. *Third Year's Courses.*—Laboratory: Qualitative and quantitative organic determinations, molecular weight determinations, gas analysis, thermo-electro and photo-chemical and other physical determinations. Lectures: General, physical, inorganic, and organic chemistry, a detailed study of special branches, and the historical development of chemistry.

Faculty of Arts.—*First Year's Course.* — Same as Faculty of Science.

Faculty of Medicine.—*First Year's Courses.*—Laboratory: Same as in Faculty of Science, but less detailed, and including the detection of the chief alkaloids, glucosides, and carbohydrates. Lectures: Same as in Faculty of Science, first year.

Faculty of Engineering.—*First Year's Courses.*—Laboratory: Same as in Faculty of Science, but less detailed, and including a special study of metals, alloys, and other materials used in building construction, also determination of hardness in waters. Lectures: Same as in the Faculty of Science, but not including organic chemistry.

Chemistry is one of the subjects required for numerous Scholarships in the Faculties of Science, Medicine, and Engineering. The Royal Commissioners for the Exhibition of 1851 offer every two years a Science Research Scholarship of £150 per annum. This Scholarship has already been held by six Chemistry Students of this College.

For details as to Fees, Regulations as to Scholarships, and other particulars apply to O'Gorman and Co., Galway.

ROYAL COLLEGE OF SCIENCE FOR IRELAND, DUBLIN.

The Royal College of Science supplies, as far as practicable, a complete course of instruction in Science applicable to the Industrial Arts, and is intended also to aid in the instruction of teachers for the Schools of Science.

Diplomas are awarded in the Faculties of Engineering (Mechanical and Electrical), Applied Chemistry, and Agriculture. If accompanied by a certificate from the Professor of Chemistry, the Diploma of Associate of the Royal College of Science in the Faculty of Applied Chemistry is recognised by the Council of the Institute of Chemistry of Great Britain and Ireland as qualifying candidates for admission to the final practical examinations of the Institute.

The instruction in Chemical Science includes (1) General Inorganic Chemistry, Elementary and Advanced; (2) Organic Chemistry, Elementary and Advanced; (3) Analytical and Experimental Chemistry; (4) Physical Chemistry; (5) Metallurgical and Technological Chemistry and Assaying; (6) Instruction in Chemical Research.

Fees payable by Non-Associate Students:—£2 for each separate Course of Lectures. For Analytical Chemistry and Research—£5 for three months; £9 for six months; £12 for the entire session. Assaying—£5 for three months; £9 for six months. £12 for the entire session.

There are six Royal Scholarships of the value of £50 each yearly, with Free Education, including Laboratory Instruction, tenable for three years; two become vacant each year; they are awarded on the results of their examinations to Associate Students, not being Royal Exhibitioners, who have been a year in the College.

A limited number of Entrance Scholarships and Teacherships-in-Training in Science and Technology are competed for each year. These Scholarships are of the value of £50 a year for four years, and, in addition, entitle the holder to free instruction during the full Associateship Course.

For further particulars apply to the Registrar.

PROFESSIONAL CHEMICAL QUALIFICATION (F.I.C. and A.I.C.).

The Institute of Chemistry of Great Britain and Ireland.—The Institute of Chemistry was founded in October, 1877, and incorporated by Royal Charter in June, 1885, to maintain the efficiency and integrity of the profession of Chemistry, including professional consulting and technological chemists, public analysts, and chemical advisers.

The Studentship. — Every Candidate for registration as a Student is required to produce evidence that he is at least seventeen years of age, and that he has passed an approved Preliminary Examination or otherwise satisfied the Council as to the standard of his general education. He must also show that, at the time of making application

for registration, he is working at a College or University recognised by the Council, or under the direction of a Fellow of the Institute in an approved laboratory or works.

The Associateship.—Candidates for the Associateship are required to produce evidence of having passed an approved preliminary examination and of having undergone four years systematic training, or the equivalent, in chemistry, physics, and allied sciences. Admission by examination is granted to candidates who have been trained, in accordance with the regulations, in a recognised University or College, or partly in such Institution and under Fellows of the Institute in laboratories or works. The Council will also consider specially and on their merits the cases of candidates who have been engaged in the study and practice of chemistry for at least ten years.

The Examination comprises, in addition to a general knowledge of all branches of chemistry, a thorough knowledge of one branch—Mineral chemistry; metallurgical chemistry; physical chemistry; organic chemistry; chemistry (including microscopy) of food and drugs, fertilisers and feeding-stuffs, soils, and water; biological chemistry; or chemical technology. Candidates are required to translate foreign technological literature, with the aid of dictionaries. Candidates taking the food and drugs section must take a course in botany, and those taking biological chemistry a course in biology.

Admission to the Associateship without examination may be granted to candidates who have obtained certain University degrees with first or second class honours in chemistry, or other specially recognised diplomas; and in exceptional cases to candidates who have otherwise complied with the conditions of the Charter with regard to age, general education, scientific training, experience, &c.

The Fellowship.—Admission to the Fellowship is open to Associates of three years standing by examination or by satisfying the Council that they have carried out original research, or have devised processes or inventions, or that they are possessed of knowledge and ability of sufficiently high order to warrant their exemption from further examination. In special cases candidates other than Associates, who have been systematically trained and have had considerable experience, may be examined for the Fellowship without passing through the grade of Associateship. In exceptional circumstances candidates who have been systematically trained and have had considerable experience, and have obtained positions of responsibility, may be elected to the Fellowship without examination.

Full particulars are given in "The Book of Regulations for the Admission of Students, Associates, and Fellows," which may be obtained (gratis) from the Registrar, 30, Russell Square, London, W.C. 1. Past Examination Papers, Annual Sets, 6d. each.

CHEMICAL LECTURES, CLASSES, AND LABORATORY INSTRUCTION.

City and Guilds of London Institute—The Institute was founded in 1878, incorporated under the Companies Acts in 1880, and received the grant of a Royal Charter by Her late Majesty Queen Victoria in 1900. It is an association of the Corporation and Livery Companies of the City of London, instituted "for the purposes of all such branches of Science and the Fine Arts as benefit or are of use to, or may benefit or be of use to, productive and technical industries especially, and to commerce and industry generally or any branch thereof, and for the utilisation of such means as will promote the several exclusive purposes aforesaid." The operations of the Institute are divided broadly into four branches:—(1) The City and Guilds (Engineering) College, (2) the City and Guilds Technical College, Finsbury, (3) the City and Guilds South London Technical Art School, and (4) the Department of Technology of the Institute. *The City and Guilds (Engineering) College, Exhibition Road, S.W.*, forms the Engineering Section of the Imperial College of Science and Technology, and is conducted by a Delegacy representing the Imperial College, the City and Guilds of London Institute, and the Goldsmiths' Company. The College was included as a School of the University of London in the Faculty of Engineering in 1898. The courses of instruction cover a period of three years, and are in Civil and Mechanical Engineering, and in Electrical Engineering. They commence once a year in October, after the Matriculation or Entrance Examination of the College, and necessitate attendance through the Session. The age of admission is over 16 years. The fee for matriculated students attending a diploma course is £38 a session, if paid in advance. *The City and Guilds Technical College, Finsbury*, provides courses of instruction in Civil, Mechanical, and Electrical Engineering, and Applied Chemistry. The courses of instruction and the practical work in the laboratories and workshops are arranged solely with the object of providing a training on broad, practical, and scientific principles, in those matters which experience has shown best to fit a student to enter some one of the many careers connected with Civil, Mechanical, Electrical, or Chemical Industries or professions. The age of admission is 15 years. There is an entrance examination once a year, in September, and the fee for the Session is £20 if paid in advance. The object of the Institute's *Department of Technology, Exhibition Road, S.W.*, is the registration and inspection of classes in all branches of Technology, Domestic Subjects, and in Manual Training, and the holding of annual examinations in the subjects taught in such classes throughout the country and in the Colonies. The Programme of the Department, including regulations for registration and inspection, and for the award of Teachers' Certificates in Manual Training and Domestic Subjects, with Syllabus of Subjects, &c., published by Mr. John Murray, Albemarle Street, London, and is obtainable through any bookseller.

City of London College, White Street, Moorfields.—A. W. Bain, B.A., B.Sc., F.I.C., and Assistants. Classes and Laboratory Practice in Chemistry, open to Students of both sexes. Courses on Commercial Products—Oils, Metals, Textiles. Session commences Sept. 29.

Battersea Polytechnic.—Inorganic, Organic, and Technological Chemistry, John Wilson, M.Sc. (Vict.), F.I.C. (Head of Chemical Department), and Assistants. Complete three or four years' day diploma courses of Instruction are given in Chemistry (Inorganic and Organic), together with Physics, Mathematics, and Engineering subjects, &c., for intending technological and works chemists. Certain of the Courses (Day and Evening) are recognised by the University of London in preparation for the B.Sc., for which examinations (Pass and Honours) complete courses of instruction, under recognised teachers, are provided. Special Evening Courses (theoretical and practical) in various Technical subjects, as Applied Bacteriology, Food and Drug Analysis, Pharmacy and Dispensing, Materia Medica, Paper Testing, Paper Making, Commercial Paper Course, Oils and Fats, Edible Fats and Oils, Lubricating Oils and Greases, Testing of Disinfectants, Chemical Engineering, and Gas Analysis. Special day and evening courses for the examination of the Institute of Chemistry, the Pharmaceutical Society, the Apothecaries' Hall, and the Conjoint Medical Board. For further information see the Polytechnic Calendar, an abridged copy of which may be obtained gratis from the Secretary of the Polytechnic.

Borough Polytechnic Institute, Borough Road, S.E. 1.—Chemistry Department under the direction of C. Dorée, M.A., D.Sc. Evening Lectures and Laboratory Work in Inorganic and Organic Chemistry. Special Lectures and Laboratory Courses in Electro-chemical Analysis, and the Chemistry and Technology of the Essential Oils. Special Courses of Lectures on various Technical subjects. (For further information see Institute Syllabus).

Birkbeck College, Breams Buildings, Chancery Lane.—Chemistry Courses conducted by G. Senter, D.Sc., Ph.D. (assisted by F. Barrow, M.Sc., E. Sugden, B Sc., and Mabel G. Barrett, B.Sc.), prepare for various Examinations, the B.Sc. and First M.B. Degrees of the London University, the First Conjoint Board, and the Examinations of the Institute of Chemistry. The S ssion will commence on Monday, Sept. 29. The Day and Evening courses of study include Chemistry, Physics, Botany, Zoology, Geology, Mathematics, Latin, Greek, Modern Languages, Economics, Geography, Logic, History, and various branches of Law. All the Courses are conducted by recognised teachers of the University and provide for the Examinations of the University of London. The Calendar supplies detailed information respecting the Courses of Study, Examinations, &c.

Northern Polytechnic Institute, Holloway, London, N.—Principal, R. S. Clay, D.Sc. Instruction in theoretical and practical Inorganic and Organic Chemistry. Systematic Day and Evening Courses for the London University Degrees, Pass and Honours, also for the Board of Education examinations. Prospectus sent free on application to the Secretary.

Northampton Polytechnic Institute, St. John Street, E C. 1.—Principal, R. Mullineux Walmsley, D.Sc., &c. Day Courses in Electro-chemistry and Engineering Chemistry, and evening classes in Electro-chemistry, Electro-plating, Engineering Chemistry, Electro-metallurgy, Electrotyping, Stereotyping, and Metal Colouring. (For full details see Prospectus). Telephone, Holborn 1194.

South Western Polytechnic Institute, Chelsea, S.W. 3, offers facilities for academic and technical education in many branches of Chemistry and Metallurgy. The department gives facilities for both day and evening courses to meet the many requirements of these professions in London, including complete courses in General Chemistry, Metallurgy, and Assaying requisite for the B.Sc. and A.I.C. Examinations, and also technical courses. A feature of the laboratory work is the opportunity given for specialising in any particular branch of the above subjects, thus supplying much needed facilities to men who have neither the time nor the necessity for attending a degree course. The various lecturers will be pleased to advise intending students with regard to selection of courses. The department is under the control of J. B. Coleman, A.R.C.S., F.I.C., F.C.S., and the aim of the Institute is to make its courses of sound practical use to those engaged in the Chemistry Industries. Further particulars on application to the Secretary (Room 79).

East London College, Mile End Road.—Chemistry: Professor, J. T. Hewitt, M.A., D.Sc., Ph.D., F.R.S.

Sir John Cass Technical Institute, Jewry Street, Aldgate.—Principal, Charles A. Keane, D.Sc., Ph.D., &c., assisted by F. J Harlow, A.R.C.S., B.Sc., H. J. S. Sand, D.Sc., Ph.D., Arthur R. Ling, F.I.C., Hugh Abbot, M.A., . O. Bannister, A.R.S.M., M.I.M.M., G Patchin, .R.S.M., Arthur Harden, D.Sc., F R.S., &c., J. S. S. rame, A. W. Young, M.A., B.Sc., Miss A. T. Anders n, .Sc., P. C. L. Thorne, M A., Douglas Betts, A.M.I.E E., . B Ransom, M.I.C.E., M.I.M.E., E. M. Boote. The w Session of the Sir John Cass Technical Institute, ich is especially devoted to technical training in Experimental Science and in the Artistic Crafts, will commence Thursday, Sept 25. The instruction in experimental Science provides systematic courses in Mathematics, Physics, and Chemistry for London University aminations in addition to the courses on higher technological instruction and on inorganic, organic, physical, l analytical chemistry, which form a special feature of work of the Institute. The curriculum in connection h the Fermentation Industries includes courses of ruction on Brewing and Malting, Bottling and Cellar nagement, and on the Micro-bi...

tion Industries. In the department of Physics ar Mathematics, special courses of Lectures will be given o Differential Equations and Vector Analysis, and on th Theory and Application of Mathematical Statistics, th latter of which will treat of the application of modern mathematical methods of dealing with statistical data i social, educational, economic, and physical problems. Opportunity will be given to students to investigate problems on their own account. Special preparatory courses are provided in this department in Mathematics and Physics for those wishing to qualify for industrial positions for which a knowledge of these subjects is essential. In the Metallurgy department, in addition to the ordinary courses, special advanced courses are provided on Gold, Silver, and allied metals, on Iron and Steel, on Metallography and Pyrometry, on Heat Treatment of Iron and Steel, on the Mechanical Testing of Metals and Alloys, and on Mechanical Drawing. Full facilities are provided for advanced practical work and research in Chemistry, Metallurgy, and Physics.

East Ham Technical College.—Principal, W. H. Barker, B Sc. (Lond.). Head of Chemical Department—E. D. Griffiths, B.Sc. (Wales). Lecturers in Pure Chemistry—J A. Stubbs, B Sc. (Lond.); R. W. Wilson, F.C.S, Hons. Board of Education; A. G. Mussell, A.I.C., Hons. Board of Education; S. J. Rogers, B.Sc. (Lond.), A.I.C. Lecturers in Applied Chemistry—A. J. Nice, First Class Honours City and Guilds of London Institute Gas Engineering and Chemical Engineering, and Tar Distillation and Products—C. J. Benedict, Bronze Medallist, Final Certificate City and Guilds of London Institute. Oils, Fats, and Waxes, and Soap Manufacture—R. A. Phillips, First Class Certificate City and Guilds of London Institute. Dye-stuffs and Colouring Matters—A. Freeborn, First Class Certificate City and Guilds of London Institute. Painters' Oils, Colours, and Varnishes.

West Ham Municipal Technical Institute, Romford Road, Stratford, E. 15.—Principal, T. C. Baillie, M.A., D.Sc. Head of Chemical Department—G. Dean, M.A. Lecturer in Pharmacy and Dispensing—W. A. Knight, Ph.C. Complete Courses in General Chemistry for B Sc. (Lond.) and A.I.C. Examinations. Evening Courses in Pharmacy and Dispensing in preparation for the Assistants Examination of the Society of Apothecaries, London.

Blackburn Municipal Technical School.—Chemistry: Robert H. Pickard, D Sc.(Lond.), F.R.S., assisted by F. J. Cooper, B. Fullman, B.Sc., Lily Letter, B.Sc., and Miss E. Holt, B.Sc. Session commences Sept. 18. Full details of the Classes are given in the "Students' Handbook," which may be had at the Institution (price 1d., by post 3d.).

Manchester College of Technology (University of Manchester).—The work of the College includes advanced study and research in various branches of science and technology, and undergraduate courses in the Faculty of Technology, extending over three years and leading to Degrees and Certificates in Mechanical Engineering, Electrical Engineering, Sanitary Engineering, Textile Industries, Printing and Photographic Technology, Architecture, and in the following branches of Applied Chemistry:—General Chemical Technology, Chemistry of Textiles (Bleaching, Dyeing, Printing, and Finishing), Paper Manufacture, Metallurgy and Assaying, Fuels, Chemical Technology of Brewing, Electro-chemistry, Photography. The provision for the teaching of Chemistry is of an exceptionally complete character. In addition to the laboratories for Inorganic and Organic Chemistry, Metallurgy, Brewing, Bleaching, Dyestuffs Manufacture, Dyeing, and Electro-chemistry, an extensive equipment (including machinery and appliances on an industrial scale) for demonstration, experiment and ...

separate building. A Brewhouse is also equipped on the low gravity principle with a plant of four bushel capacity.

Technical College, Swansea.—Acting Principal, T. Gilbert Jones, M.Sc., Wh.Sc., A.M.I.C.E., A.M.I.E.E. Chemistry, E. A. Tyler, M.A.; Metallurgy, H. I. Coe, M.Sc.; Physics, J. C. Kirkman, B.Sc. Day and Evening Courses in Pure and Applied Chemistry, Chemical Engineering, Metallurgy, and for Pharmaceutical, Medical, and Dental Students. Session opens Sept. 22nd.

Wolverhampton Municipal Science and Technical School.—Inorganic and Organic Chemistry, Th. J. Murray, M.Sc., Ph.D., F.I C., and R. H. Hopkins, B.Sc., F.I.C.; Physics, A. T. Harrison, B.Sc.; Botany, W. J. Fitzgerald, B.A. Materia Medica and Pharmacy, F. W. Thompson, Ph.C. Day Classes in Chemistry, and Evening Classes in Chemistry, Physics, Botany, French, &c. Special arrangements are made for the requirements of Pharmaceutical and Medical Students and Chemical Trades. Session commences Sept. 15th. For other particulars and programme, apply G. F. Chell, Secretary.

Municipal Technical Institute, Belfast.—Vice-Principal, J. Earles, B.A. Chemistry, Prof. H. Wren, M.A., Ph.D., D.Sc. Day and Evening Courses.

HOW THE NITROGEN PROBLEM HAS BEEN SOLVED.*

By HENRY JERMAIN MAUDE CREIGHTON, Department of Chemistry, Swarthmore College, Member of the Institute.

(Continued from p. 113.

VI. The Oxidation of Ammonia.

Since, with the exception of the arc process, all methods for the fixation of atmospheric nitrogen yield products which are readily converted into ammonia, its oxidation to nitric acid is one of the most important phases of the nitrogen problem. Although it was discovered in 1830 by Kühlmann that ammonia could be oxidised in the presence of platinum, it was not until the process was developed by Ostwald in 1902 that it became of technical importance. During the past few years various methods have been developed which effect the direct oxidation of ammonia by air in the presence of a catalyst.

Outline of the Principles Underlying the Oxidation of Ammonia.

When a mixture of ammonia and air is allowed to flow through a heated catalyst (sometimes called the "burner") nitric oxide is formed in accordance with the equation—

27. $4NH_3+5O_2=4NO+6H_2O+220,000$ cal.

The oxide produced by this reaction can then be converted into nitric acid in a manner similar to that previously described under arc processes.

At low temperatures little or no nitric oxide is formed, but as the temperature is raised the rate of oxidation increases very rapidly, reaches a maximum at about 750° C., and then rapidly decreases, owing to the decomposition of the ammonia into its constituents. This change is shown graphically by the heavy curve ("conversion curve") in Fig. 14, for otherwise constant conditions, such as the composition of the gas mixture, rate of flow through the catalyst, &c.

The reaction is highly exothermic, the heat of reaction being practically constant and equal to 53,000 grm. calories between 500° C. and 700° C. It has been calculated that, under the usual conditions of oxidation and on the assumption of 100 per cent conversion, the heat of reaction is sufficient to raise the temperature of the moving gas mixture to 675° C. at the catalyst. If, therefore, the initial temperature of the ammonia-air mixture is 25° C., the temperature of the catalyst will be raised to 700° C. The smaller the percentage of ammonia converted into nitric oxide the smaller will be the rise in temperature due to the heat developed during the reaction, and the lower will be the temperature of the catalyst. The variation in the temperature of the catalyst with change in the percentage of ammonia converted is shown by the straight line ("heat-of-reaction line") in Fig. 14.

In a theoretical discussion of the conditions of stability of ammonia oxidation, Liljenroth (*Chem. Met. Eng.*, 1918, xix., 287), in a recent paper, states:—Since "the heat-of-reaction line cuts the conversion curve ordinarily at two points, *a* and *b* (Fig. 14), it seems, therefore, as if it would be possible to have two points of operation for any burner (heated catalyst) at a given gas composition and gas flow. But a closer investigation shows that the reaction cannot be maintained at the point *b* because the conditions for stability at this point are not fulfilled. Suppose that the burner is working at this point and that for some reason the temperature decreases by the small amount *dt*. Then the conversion will decrease to the point 1. This decrease will cause the temperature to be lowered still more to point 2, and this in turn will cause a new decrease in the conversion, to point 3, and so on.

"If we assume that for some reason the temperature increases, it will in the same way be found that even in this case we move away from the point of intersection, which is indicated in the illustration by the arrows pointing apart from this point.

"If we treat the other point of intersection similarly (point *a*), it will be found that the conditions are just opposite. If for some reason we depart from the point, we will immediately be carried back to it, which is indicated by the two arrows, both pointing toward the point. Point *b* is therefore an unstable location, while point *a* is a stable one. As can easily be understood, this characteristic difference depends upon the manner in which the heat-of-reaction line cuts the conversion curve. In order to obtain stability, the heat-of-reaction line must cut the conversion curve from below, and from this it follows that the part of the conversion curve to the left of the tangential point *c* is unstable, but that the part to the right is stable. It will also be understood that the stability or unstability increases with increase in the size of the angle at which the line and the curve cut each other.

"From what has been said regarding the unstability of the point *b*, we can now understand that the ammonia oxidation process is not self-starting or self-exciting, but that the gas, in order that the reaction may be started, must be heated by a flame of electricity" to the ignition temperature T, which lies considerable below the reaction temperature, after which the external heating may be interrupted and the reaction will move to the point *a*.

In practice the conversion curve and the heat-of-reaction line continually change their positions, on account of small variations in the composition and velocity of the gas mixture. A decrease in the ammonia content of the gas mixture causes the heat-of-reaction line to turn counter-clockwise about its point on the abscissa. "Ample margin between the points *a* and *c* must therefore be provided. If the top of the conversion curve is sharp it will be impossible to work at a maximum efficiency, because we have to move the working point farther to the right side, sacrificing efficiency in order to obtain stability. This also implies higher temperature. If the conversion curve is very flat, which seems to be the case in the ammonia oxidation reaction, it will be possible to work not only at the top point, but even a little to the left of it."

Of the various catalysts that have been employed for the oxidation of ammonia, the most satisfactory is platinum gauze of fine mesh, or smooth platinum the surface of which has been roughened by the deposition of a layer of platinum sponge. Platinum black or sponge alone is much too active. The best results are obtained with a thin layer of the catalyst, as a thick layer, or a low

* From the *Journal of the Franklin Institute*, April, May, and June, 1919.

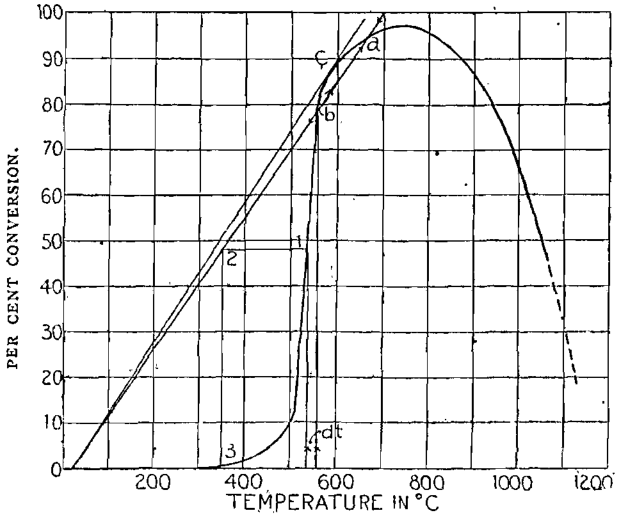

Fig. 14.

gas velocity, causes the nitric oxide that is formed to break down into its constituents. Other catalysts which have given good results are palladium, iridium, rhodium, iron, and the oxides manganese, lead, silver, copper, chromium, nickel, cobalt, vanadium, and molybdenum, especially the higher oxides.

Particularly good results have been obtained in England with iron catalysts which have been activated with certain metals ("promoters") such as copper, bismuth, cerium, tungsten, &c. The percentage conversion obtained at 700° C. with a number of these activated iron catalysts is given in Table X., the time of contact of the gas mixture with the catalyst being 0·015 second.

Table X.

Catalyst.	Percentage conversion.
Pure iron	83·5
Iron-copper	86·0
Iron-thorium	87·3
Iron-tungsten	89·3
Iron-cerium	90·0
Iron-bismuth	92·0

The relative efficiency of these catalysts at different rates of flow of the gas mixture, and at 700° C., is shown graphically in Fig. 15.

Like all catalytic processes, the oxidation of ammonia suffers from the disadvantage that the catalyst is liable to be poisoned. It is necessary, therefore, to remove from the ammonia by suitable methods of purification all substances which poison the catalyst. While it has been believed that the presence of acetylene in the ammonia-air mixture had a marked deleterious effect on the platinum in the oxidation of ammonia, recent experiments have shown this to be due to the presence of phosphine and not to acetylene. The presence of 2 to 3 parts per hundred million of phosphine in the ammonia-air mixture lowers the yield of nitric oxide several per cent, while ten times this amount is ruinous. It is probable that the action of phosphine is cumulative, since the platinum appears to become less efficient with use.

(To be continued).

Appointment.—Mdme. Sklodowska Curie has been appointed Professor of Radiology in the Warsaw University.

CORRESPONDENCE.

COLOURING MATTER OF "BLUE JOHN."

To the Editor of the Chemical News.

Sir,—In reference to the above, Mr. A. Norman Tate, F.C.S., F.G.S., read a paper before the Liverpool Geological Society on April 10, 1888. Before the paper was read I asked Mr. Tate if he had detected manganese in the mineral. He replied in the negative. In his printed paper he says—"I am led to believe that the colouring matter consists largely of organic or hydrocarbon matters, which are destroyed on heating. Mr. Tate omits his analysis of the mineral, though he gives several experiments made with it to learn if volatile matter were evolved on heating. Heat destroyed the colour, and on cooling it was not restored."

See *Proceedings* of the Liverpool Geological Society, Session 29th.

If my memory serves me, Prof. Church attributed the colour of a marble or a limestone that he examined to organic matter.—I am, &c.,

Philip Holland.

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BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

BOURNEMOUTH, 1919.

INAUGURAL ADDRESS OF THE PRESIDENT,

The Hon. Sir CHARLES A. PARSONS,
K.C.B., M.A., LL.D., D.Sc., F.R.S.

THREE years of anxiety and stress have passed since the last meeting of the British Association. The weight of the struggle which pressed heavily upon us at the time of the Newcastle Meeting in 1916 had increased so much in intensity by the Spring of 1917 that the Council, after consultation with the Local Committee at Bournemouth, finally decided to cancel the Summer Meeting of that year. This was the first time in the history of the Association that the Annual Meeting was not held.

We all rejoice to feel that the terrible ordeal through which the whole Empire has been passing has now reached its final phases, and that during the period of reorganisation, social and industrial, it is possible to resume the Annual Meetings of the Association under happier conditions. We have gladly and with much appreciation accepted the renewed invitation of our friends and colleagues at Bournemouth.

We are gathered together at a time when, after a great upheaval, the elemental conditions of organisation of the world are still in flux, and we have to consider how to influence and mould the recrystallisation of these elements into the best forms and most economic rearrangements for the benefit of civilisation. That the British Association is capable of exerting a great influence in guiding the nation towards advancement in the Sciences and Arts in the most general sense there can be no question, and of this we may be assured by a study of its proceedings in conjunction with the history of contemporary progress. Although the British Association cannot claim any paramount prerogative in this good work, yet it can certainly claim to provide a free arena for discussion where in the past new theories in Science, new propositions for beneficial change, new suggestions for casting aside fetters to the advancement in Science, Art, and Economics have first seen the light of publication and discussion.

For more than half a century it has pleaded strongly for the advancement of Science and its application to the Arts. In the yearly volume for 1855 will be found a report in which it is stated that "The Objects for which the Association was established have been carried out in three ways: First, by requisitioning and printing reports on the present state of different branches of Science; secondly, by granting sums of money to small committees or individuals, to enable them to carry on new researches; thirdly, by recommending the Government to undertake expeditions of discovery, or to make grants of money for certain and national purposes, which were beyond the means of the Association." As a matter of fact it has, since its commencement, paid out of its own funds upwards of £80,000 in grants of this kind.

Developments Prior to the War.

It is twenty-nine years since an engineer, Sir Frederick Bramwell, occupied this Chair and discoursed so charmingly on the great importance of the next to nothing, the importance of looking after little things which, in engineering, as in other walks of life, are often too lightly considered.

The advances in engineering during the last twenty years are too many and complex to allow of their description, however short, being included in one Address, and, following the example of some of my predecessors in this Chair, I shall refer only to some of the most important features of this wide subject. I feel that I cannot do better than begin by quoting from a speech made recently by Lord Inchcape, when speaking on the question of the nationalisation of coal:—"It is no exaggeration to say that coal has been the maker of modern Britain, and that those who discovered and developed the methods of working it have done more to determine the bent of British activities and the form of British society than all Parliaments of the past hundred and twenty years."

James Watt.—No excuse is necessary for entering upon this theme, because this year marks the anniversary of the death of James Watt, and in reviewing the past, it appears that England has gained her present proud position by her early enterprise and by the success of the Watt steam-engine, which enabled her to become the first country to develop her resources in coal, and led to the establishment of her great manufactures and her immense mercantile marine.

The laws of steam which James Watt discovered are simply these:—That the latent heat is nearly constant for different pressures within the ranges used in steam-engines, and that, consequently, the greater the steam pressure and the greater the range of expansion the greater will be the work obtained from a given amount of steam. Secondly, as may now seem to us obvious, that steam from its expansive force will rush into a vacuum. Having regard to the state of knowledge at the time, his conclusions appear to have been the result of close and patient reasoning by a mind endowed with extraordinary powers of insight into physical questions, and with the faculty of drawing sound practical conclusions from numerous experiments devised to throw light on the subject under investigation. His resource, courage, and devotion were extraordinary.

In commencing his investigations on the steam-engine he soon discovered that there was a tremendous loss in the Newcomen engine, which he thought might be remedied. This was the loss caused by condensation of the steam on the cold metal walls of the cylinder. He first commenced by lining the walls with wood, a material of low thermal conductivity. Though this improved matters, he was not satisfied; his intuition probably told him that there should be some better solution of the problem, and doubtless he made many experiments before he realised that the true solution lay in a condenser separate from the cylinder of the engine. It is easy after discovery to say, "How obvious and how simple," but many of us here know how difficult is any step of advance when shrouded by unknown surroundings, and we can well appreciate the courage and the amount of investigation necessary before James Watt thought himself justified in trying the separate condenser. But to us now, and to the youngest student who knows the laws of steam as formulated by Carnot, Joule, and Kelvin, the separate condenser is the obvious means of constructing an economical condensing engine.

Watt's experiments led him to a clear view of the great importance of securing as much expansion as possible in his engines. The materials and appliances for boiler and machine construction were at that time so undeveloped that steam pressures were practically limited to a few pounds above atmospheric pressure. The cylinders and pistons of his engines were not constructed with the facility and accuracy to which we are now accustomed, and chiefly for these reasons expansion ratios of from two to threefold were the usual practice. Watt had given to the world an engine which consumed from five to seven pounds of coal per horse-power hour, or one-quarter of the

fuel previously used by any engine. With this consumption of fuel its field under the conditions prevailing at the time was practically unlimited. What need was there, therefore, for commercial reasons, to endeavour still further to improve the engine at the risk of encountering fresh difficulties and greater commercial embarrassments? The course was rather for him and his partners to devote all their energy to extend the adoption of the engine as it stood, and this they did, and to the Watt engine, consuming from five to seven pounds of coal per horse-power, mankind owes the greatest permanent advances in material welfare recorded in history.

With secondary modifications, it was the prime mover in most general use for eighty years—*i.e.*, till the middle of last century. It remained for others to carry the expansion of steam still further in the compound, triple, and, lastly, in the quadruple expansion engine, which is the most economical reciprocating engine of to-day.

Watt had considered the practicability of the turbine. He writes to his partner, Boulton, in 1784:—"The whole success of the machine depends on the possibility of prodigious velocities. In short, without God makes it possible for things to move them one thousand feet per second, it cannot do us much harm." The advance in tools of precision, and a clearer knowledge of the dynamics of rotating bodies, have now made the speeds mentioned by Watt feasible, and, indeed, common everyday practice.

Turbines.—The turbine of to-day carries the expansion of steam much further than has been found possible in any reciprocating engine, and owing to this property it has surpassed it in the economy of coal, and it realises to the fullest extent Watt's ideal of the expansion of steam from the boiler to the lowest vapour pressure obtainable in the condenser.

Among the minor improvements which in recent years have conduced to a higher efficiency in turbines are the more accurate curvature of the blades to avoid eddy losses in the steam, the raising of the peripheral velocities of the blades to nearly the velocity of the steam impinging upon them, and details of construction to reduce leakages to a minimum. In turbines of 20,000 to 30,000 horse-power 82 per cent of the available energy in the steam is now obtainable as brake horse-power, and with a boiler efficiency of 85 per cent the thermo dynamic efficiency from the fuel to the electrical output of the alternator has reached 23 per cent, and shortly may reach 28 per cent, a result rivalling the efficiency of internal combustion engines worked by producer gas.

During the twenty years immediately preceding the war turbo generators had increased in size from 500 kilowatts to 25,000 kilowatts, and the consumption of steam had fallen from 17 lb. per kw. hour to 10·3 lb. per kw. hour. Turbines have become the recognised means of generating electricity from steam on a large scale, although they have not superseded the Watt engine for pumping mines or the drawing of coal, except in so far as it is a means for generating electricity for these purposes. In the same period the engine power in the mercantile marine had risen from 3900 of the *King Edward* to 75,000 of the *Mauretania.*

As regards the Royal Navy, the engine power of battleships, prior to the war, had increased from 12,000 i.h.p. to 30,000 s.h.p., while the speed advanced from 17 knots to 23 knots, and during the war, in ships of the *Queen Elizabeth* class, the power amounted to 75,000 s.h.p. with a speed of 25 knots. In cruisers similar advances were made. The i.h.p. of the *Powerful* was 25,000, while the s.h.p. of the *Queen Mary* was 78,000, with a speed of 28 knots. During the war the power obtained with geared turbines in the *Courageous* class was 100,000 s.h.p. with a speed of 32 knots, the maximum power transmitted through one gear wheel being 25,000 h.p., and through one pinion 15,500 h.p., while in destroyers, speeds up to 39 knots have been obtained. The aggregate horse-power of war and mercantile turbined vessels throughout the world is now about 35 millions.

These advances in power and speed have been made possible mainly by the successive increase in economy and diminution of weight derived from the replacement of reciprocating engines by turbines direct coupled to the propellers, and, later, by the introduction of reduction gearing between the turbines and the propellers; also by the adoption of water-tube boilers and of oil fuel. With these advances the names of Lord Fisher, Sir William White, and Sir Henry Oram will always be associated.

The Work of Sir Wm. White.—With the great work of the Royal Navy fresh in our minds, we cannot but recall the prominent part taken by the late Sir William White in its construction. His sudden death, when President-elect for 1913, lost to the nation and to the Association the services of a great naval architect who possessed remarkable powers of prevision and dialectic. He was Chief Constructor to the Admiralty from 1885 to 1901, and largely to him was due the efficiency of our vessels in the Great War.

White often referred to the work of Brunel as the designer of the *Great Eastern*, and spoke of him as the originator of the cellular construction of the bottoms of ships, since universally adopted, as a means of strengthening the hull and for obtaining additional safety in case of damage. Scott Russell was the builder of this great pioneer vessel, the forerunner of the Atlantic liners, and the British Association may rightly feel satisfaction in having aided him when a young man by pecuniary grants to develop his researches into the design aad construction of ships and the wave-line form of hull which he originated, a form of special importance in paddle-wheel vessels.

So much discussion has taken place in the last four years as to the best construction of ship to resist torpedo attacks that it is interesting to recall briefly at the present time what was said by White in his Cantor Lectures to the Royal Society of Arts in 1906:—"Great attention has been bestowed upon means of defence against underwater torpedo attacks. From the first introduction of torpedoes it was recognised that extreme watertight subdivision in the interior of warships would be the most important means of defence. Experiments have been made with triple watertight skins forming double cellular sides, the compartments nearest the outer bottom being filled, in some cases, with water, coal, cellulose, or other materials. Armour plating has been used both on the outer bottom and on inner skins." He also alludes to several Russian ships which were torpedoed by the Japanese, and he concludes by saying:—"Up to date the balance of opinion has favoured minute watertight subdivisions and comparatively thin watertight compartments, rather than the use of internal armour, whose use, of course, involves large expenditure of weight and cost."

The present war has most amply confirmed his views and conclusions, then so lucidly and concisely expressed.

While on the subject of steamships, it may perhaps be opportune to say one word as to their further development. The size of ships had been steadily increasing up to the time of the war, resulting in a reduction of power required to propel them per ton of displacement. On the other hand, thanks to their greater size and more economical machinery, speeds have been increased when the traffic has justified the greater cost. The limiting factor to further increase in size is the depth of water in the harbours. With this restriction removed there is no obstacle to building ships up to 1000 feet in length or more, provided the volume and character of the traffic are such as to justify the capital outlay.

Tungsten Steel.—Among other important pre-war developments that have had a direct bearing upon the war, mention should be made of the discovery and extensive use of alloys of steel. The wonderful properties conferred upon steel by the addition of tungsten were discovered by Muschet in 1868, who has not been sufficiently credited with his share in making the Bessemer process a practical success, and later this alloy was investigated and improved

by Maunsel White and Taylor, of Philadelphia. The latter showed that the addition of tungsten to steel has the following effect:—That after the steel has been quenched at a very high temperature near its melting-point it can be raised to a much higher temperature than is possible with ordinary carbon tool steel, without losing its hardness and power of cutting metal. In other words, it holds the carbon more tenaciously in the hardened state, and hence tungsten steel tools, even when red hot, can cut ordinary mild steel. It has revolutionised the design of machine tools and has increased the output on heavy munition work by 100 per cent, and in ordinary engineering by 50 per cent.

The alloys of steel and manganese with which Sir Robert Hadfield's name is associated have proved of utility in immensely increasing the durability of railway and tramway points and crossings, and for the hard teeth of machinery for the crushing of stone and other materials, and, in fact, for any purposes where great hardness and strength are essential.

Investigation of Gaseous Explosions.—Brief reference must also be made—and it will be gratifying to do so—to the important work of one of the Committees of the British Associations appointed in 1908, under the Chairmanship of the late Sir William Preece, for the investigation of gaseous explosions, with special reference to temperature. The investigations of the Committee are contained in seven yearly reports up to 1914. Of the very important work of the Committee I wish to refer to one investigation in particular, which has proved to be a guiding star to the designers and manufacturers of internal combustion engines in this country. The members of Committee more directly associated with this particular investigation were Sir Dugald Clerk, Professor Callendar, and the late Professor Bertram Hopkinson.

The investigation showed that the intensity of the heat radiated by the incandescent gases to the walls of the cylinder of a gas engine increases with the size of the cylinder, the actual rate of this increase being approximately proportional to the square root of the depth of the radiating incandescent gas; the intensity was also shown to increase rapidly with the richness of the gas. It suffices now to say that the heat in a large cylinder with a rich explosive mixture is so intense that the metal eventually cracks. The investigation shows why this occurs, and by doing so has saved enormous sums to the makers of gas and oil engines in this country, and has led them to avoid the large cylinder, so common in Germany before the war, in favour of a multiplicity of smaller cylinders.

Science and the War.

In coming to this section of my Address I am reminded that in the course of his Presidential Address to Section G, in 1858, Lord Rosse said:—"Another object of the Mechanical Section of the Association has been effected—the importance of engineering science in the service of the State has been brought more prominently forward. There seems, however, something still wanting. Science may yet do more for the Navy and Army if more called upon."

Comparatively recently, too, Lord French remarked:—"We have failed during the past to read accurately the lessons as regards the fighting of the future which modern science and invention should have taught us."

In view of the eminent services which scientists have rendered during the war, I think that we may be justified in regarding the requirements stated by Lord Rosse as having at last been satisfied, and also in believing that such a criticism as Lord French rightly uttered will not be levelled against the country in the future.

Though British men of Science had not formerly been adequately recognised in relation to war and the safety of their country, yet at the call of the sailors and the soldiers they whole-heartedly, and with intense zeal, devoted themselves to repair the negligence of the past, and to apply their unrivalled powers and skill to encounter and overcome the long-standing machinations of the enemy. They worked in close collaboration with the men of Science of the Allied Nations, and eventually produced better war material, chemicals, and apparatus of all kinds for vanquishing the enemy and the saving of our own men than had been devised by the enemy during many years of preparation planned on the basis of a total disregard of treaties and the conventions of war.

Four years is too short a time for much scientific invention to blossom to useful maturity, even under the forced exigencies of war and Government control. It must be remembered that in the past the great majority of new discoveries and inventions of merit have taken many years—sometimes generations—to bring them into general use. It must also be mentioned that in some instances discoveries and inventions are attributable to the general advance in Science and the Arts which has brought within the region of practical politics an attack on some particular problem. So the work of the scientists during the war has perforce been directed more to the application of known principles, trade knowledge, and properties of matter to the waging of war, than to the making of new and laborious discoveries; though, in effecting such applications, inventions of a high order have been achieved, some of which promise to be of great usefulness in time of peace.

The advance of Science and the Arts in the last century had, however, wrought a great change in the implements of war. The steam engine, the internal combustion engine, electricity, and the advances in metallurgy and chemistry had led to the building up of immense industries which, when diverted from their normal uses, have produced unprecedented quantities of war material for the purposes of the enormous armies, and also for the greatest Navy which the world has ever seen.

The destructive energy in the field and afloat has multiplied many hundredfold since the time of the Napoleonic wars; both before and during the war the size of guns and the efficiency of explosives and shell increased immensely, and many new implements of destruction were added. Modern science and engineering enabled armies unprecedented in size, efficiency, and equipment to be drawn from all parts of the world and to be concentrated rapidly in the fighting line.

To build up the stupendous fighting organisation, ships have been taken from their normal trade routes, locomotives and material from the home railways, the normal manufactures of the country have been largely diverted to munitions of war; the home railways, tramways, roads, buildings and constructions, and material of all kinds have been allowed to depreciate. The amount of depreciation in roads and railways alone has been estimated at 400 millions per annum at present prices. Upon the community at home a very great and abnormal strain has been thrown, notwithstanding the increased output per head of the workers derived from modern methods and improved machinery. In short, we have seen for the first time in history nearly the whole populations of the principal contending nations enlisted in intense personal and collective effort in the contest, resulting in unprecedented loss of life and destruction of capital.

A few figures will assist us to realise the great difference between this war and all preceding wars. At Waterloo, in 1815, 9044 artillery rounds were fired, having a total weight of 37·3 tons, while on one day during the last offensive in France, on the British Front alone, 943,837 artillery rounds were fired, weighing 18,080 tons—over 100 times the number of rounds, and nearly 540 times the weight of projectiles. Again, in the whole of the South African War, 273,000 artillery rounds were fired, weighing approximately 2800 tons; while during the whole war in France, on the British Front alone, over 170 million artillery rounds were fired, weighing nearly $3\frac{1}{2}$ million tons—622 times the number of rounds, and about 1250 times the weight of projectiles.

However great these figures in connection with modern land artillery may be, they become almost insignificant when compared with those in respect of a modern naval battle squadron. The *Queen Elizabeth* when firing all her guns discharges 18 tons of metal and develops 1,870,000 foot-tons of energy. She is capable of repeating this discharge once every minute, and when doing so develops by her guns an average of 127,000 effective horse-power, or more than one and a-half times the power of her propelling machinery; and this energy is five times greater than the maximum average energy developed on the Western Front by British guns. Furthermore, if all her guns were fired simultaneously they would for the instant be developing energy at the rate of 13,132,000 horse-power. From these figures we can form some conception of the vast destructive energy developed in a modern naval battle.

Engineering and the War.

With regard to the many important engineering developments made during the war, several papers by authorities are announced in the syllabus of papers constituting the sectional proceedings of this year's Meeting. Among them are "Tanks," by Sir Eustace d'Eyncourt; "Scientific Progress of Aviation during the War," by Dr. Bairstow; "Airships," by Lieut.-Col. Cave-Brown-Cave; "Directional Wireless, with Special Reference to Aircraft," by Capt. Robinson; "Wireless in Aircraft," by Major Erskine Murray; "Wireless Telegraphy during the First Three Years of the War," by Major Vincent Smith: "Submarine Mining," by Com. Gwynne; "Emergency Bridge Construction," by Prof. Ingles; and "The Paravane," by Com. Burney. Accordingly, it is quite unnecessary here to particularise further except in the few following instances:—

Sound-ranging and Listening Devices.—Probably the most interesting development during the war has been the extensive application of sound-listening devices for detecting and localising the enemy. The Indian hunter puts his ear to the ground to listen for the sound of the footsteps of his enemy. So in modern warfare science has placed in the hands of the sailor and soldier elaborate instruments to aid the ear in the detection of noises transmitted through earth, water, air, or ether, and also in some cases to record these sounds graphically or photographically, so that their character and the time of their occurrence may be tabulated.

The sound-ranging apparatus developed by Professor Bragg and his son, by which the position of an enemy gun can be determined from electrically recorded times at which the sound-wave from the gun passes over a number of receiving stations, has enabled our artillery to concentrate their fire on the enemy's guns, and often to destroy them.

The French began experimenting in September, 1914, with methods of locating enemy guns by sound. The English section began work in October, 1915, adopting the French methods in the first instance. By the end of 1916 the whole Front was covered, and sound-ranging began to play an important part in the location of enemy batteries. During 1917 locations by sound-ranging reached about 30,000 for the whole army, this number being greater than that given by any other means of location. A single good set of observations could be relied upon to give the position of an enemy gun to about 50 yards at 7000 yards range. It could also be carried on during considerable artillery activity.

The apparatus for localising noises transmitted through the ground has been much used for the detection of enemy mining and counter-mining operations. Acoustic tubes, microphones, and amplifying valves have been employed to increase the volume of very faint noises.

For many years before the war the Bell Submarine Signalling Company, of which Sir William White was one of the early directors, used submerged microphones for detecting sound transmitted through the water, and a submerged bell for sending signals to distances up to one mile. With this apparatus passing ships could be heard at a distance of nearly a mile when the sea was calm and the listening vessel stationary.

Of all the physical disturbances emitted or produced by a moving submarine, those most easily detected, and at the greatest distance, are the pressure waves set up in the water by vibrations produced by the vessel and her machinery. A great variety of instruments have been devised during the war for detecting these noises, depending on microphones and magnetophones of exceedingly high sensitivity. Among them may be particularly mentioned the hydrophones devised by Captain Ryan and Professor Bragg, being adaptations of the telephone transmitter to work in water instead of air. These instruments, when mounted so as to rotate, are directional, being insensitive to sound waves whose front is perpendicular to the plane of the diaphragm, and giving the loudest sound when the diaphragm is parallel to the wave front.

Another preferable method for determining direction is to use two hydrophones coupled to two receivers, one held to each ear. This is called the biaural method, and enables the listener to recognise the direction from which the sound emanates.

When the vessel is in motion or the sea is rough the water noises from the dragging of the instrument through the water and from the waves striking the ship drown the noises from the enemy vessel, and under such conditions the instruments are useless. This assistance of eminent biologists was of invaluable help at this juncture. Experiments were made with sea-lions by Sir Richard Paget, who found that they have directional bearing under water up to speeds of 6 knots. Also Professor Keith explained the construction of the hearing organs of the whale, the ear proper being a capillary tube, too small to be capable of performing any useful function in transmitting sound to the relatively large aural organs, which are deep set in the head. The whale therefore hears by means of the sound waves transmitted through the substance of the head. It was further seen that the organs of hearing of the whale to some degree resembled the hydrophone.

The course now became clear. Hollow towing bodies in the form of fish or porpoises were made of celluloid, varnished canvas, or very thin metal, and the hydrophone suitably fixed in the centre of the head. The body is filled with water, and the cable towing the fish contains the insulated leads to the observer on board the vessel. When towed at some distance behind the chasing ship disturbing noises are small, and enemy noises can be heard up to speeds of 14 knots, and at considerable distances. Thermionic amplifying valves have been extensively used, and have added much to the sensitiveness of the hydrophone in its many forms.

After the loss of the *Titanic* by collision with an iceberg, Lewis Richardson was granted two patents in 1912 for the detection of above-water objects by their echo in the air, and under-water objects by the echo transmitted through the water. The principles governing the production and the concentration of beams of sound are described in the specification, and he recommends frequencies ranging from 4786 to 100,000 complete vibrations per second, and also suggests that the rate of approach or recession from the object may be determined from the difference in the pitch of the echo from the pitch of the blast sent out. Hiram Maxim also suggested similar apparatus a little later.

The echo method of detection was not, however, practically developed until French and English scientists, with whom was associated Professor Langevin, of the College de France, realising its importance for submarine detection, brought the apparatus to a high degree of perfection and utility shortly before the Armistice. Now, with beams of high-frequency sound waves, it is possible to sweep the seas for the detection of any submerged object, such as icebergs, submarines, surface vessels, and rocks; they may also be used to make soundings. It

enables a chasing ship to pick up and close in on a submarine situated more than a mile away.

The successful development of sound-ranging apparatus on land led to the suggestion by Professor Bragg that a modified form could be used to locate under-water explosions. It has been found that the shock of an explosion can be detected hundreds of miles from its source by means of a submerged hydrophone, and that the time of arrival of the sound wave can be recorded with great precision. At the end of the war the sound-ranging stations were being used for the detection of positions at sea, required for strategical purposes. The same stations are now being used extensively for the determination of such positions at sea as light-vessels, buoys which indicate channels, and obstructions such as sunken ships. By this means ships steaming in fog can be given their positions with accuracy for ranges up to 500 miles.

Among the many other important technical systems and devices brought out during the war which will find useful application under peace conditions as aids to navigation I may mention directional wireless, by which ships and aircraft can be given their positions and directed, and on this subject we are to have a paper in Section G.

Leader gear, first used by the Germans to direct their ships through their minefields, and subsequently used by the Allies, consists of an insulated cable laid on the bottom of the sea, earthed at the further end, and through which an alternating current is passed. By means of delicate devices installed on a ship, she is able to follow the cable at any speed with as much precision as a railless electric 'bus can follow its trolley wire. Cables up to 50 miles long have been used, and this device promises to be invaluable to ships navigating narrow and tortuous channels and entering or leaving harbours in a fog.

Aircraft.—It may be justly said that the development in aircraft design and manufacture is one of the astonishing engineering feats of the war. In August, 1914, the British Air Services possessed a total of 272 machines, whereas in October, 1918, just prior to the Armistice, the Royal Air Force possessed over 22,000 effective machines. During the first twelve months of the war the average monthly delivery of aeroplanes to our Flying Service was 50, while during the last twelve months of the war deliveries were 2700 per month. So far as aero-engines are concerned, our position in 1914 was by no means satisfactory. We depended for a large proportion of our supplies on other countries. In the Aerial Derby of 1913, of the eleven machines that started, not one had a British engine. By the end of the war, however, British aero-engines had gained the foremost place in design and manufacture, and were well up to the requirements as regards supply. The total horse-power produced in the last twelve months of the war approximated to eight millions of brake horse-power, a figure quite comparable with the total horse-power of the marine engine output of the country. (See Lord Weir's paper read at the Victory meeting of the North-East Coast Institution of Engineers and Shipbuilders, July, 1919).

Much might be written on the progress in aircraft, but the subject will be treated at length in the sectional papers. In view of the recent trans-Atlantic flights, however, I feel that it may be opportune to make the following observations on the comparative utility of aeroplanes and airships for commercial purposes. In the case of the aeroplane, the weight per horse-power increases with the size, other things being equal. This increase, however, is met to some extent by a multiplicity of engines, though in the fusilage the increase remains.

On the other hand, with the airship the advantage increases with the size, as in all ships. The tractive effort per ton of displacement diminishes in inverse proportion to the dimensions, other things, including the speed, being the same. Thus, an airship of 750 feet length and 60 tons displacement may require a tractive force of 5 per cent, or 3 tons, at 60 miles per hour, and one of 1500 feet in length and $8 \times 60 = 480$ tons displacement would only require $2\frac{1}{2}$ per cent $\times 480 = 12$ tons at the same speed, and would carry fuel for double the distance.

With the same proportion of weight of hull to displacement, the larger airship would stand double the wind pressure, and would weather storms of greater violence and hailstones of greater size. It would be more durable, the proportional upkeep would be less, and the proportional loss of gas considerably less. In other words, it would lose a less proportion of its buoyancy per day. It is a development in which success depends upon the project being well thought out and the job being thoroughly well done. The equipment of the airsheds with numerous electric haulage winches, and all other appliances to make egress and ingress to the sheds safe from danger and accident, must be ample and efficient.

The airship appears to have a great future for special commerce where time is a dominant factor and the demand is sufficient to justify a large airship. It has also a great field in the opening up of new countries where other means of communication are difficult. The only limitation to size will be the cost of the airship and its sheds, just as in steam vessels it is the cost of the vessels and the cost of deepening the harbours that limit the size of Atlantic liners.

Such developments generally take place slowly, otherwise failures occur—as in the case of the *Great Eastern*—and it may be many years before the airship is increased from the present maximum of 750 feet to 1500 feet with success, but it will assuredly come. If, however, the development is subsidised or assisted by Government, incidental failures may be faced with equanimity and very rapid development accomplished. (The literature on this subject includes an article which appeared in *Engineering* on January 3, 1919). In peace time the seaplane, aeroplane, and airship will most certainly have their uses. But, except for special services of high utility, it is questionable whether they will play more than a minor part as compared with the steamship, railway, and motor transport.

Electricity.—The supply and use of electricity has developed rapidly in recent years. For lighting it is the rival of gas, though each has its advantages. As a means of transmitting power over long distances it has no rival, and its efficiency is so high that when generated on a large scale and distributed over large areas it is a cheap and reliable source of power for working factories, tramways, suburban railways, and innumerable other purposes, including metallurgical and chemical processes. It is rapidly superseding locally generated steam-power, and is a rival to the small and moderate-sized gas and oil engines. It has made practicable the use of water-power through the generation of electricity in bulk at the natural falls, from which the power is transmitted to the consumers, sometimes at great distances.

Fifteen years ago electricity was generated chiefly by large reciprocating steam engines, direct coupled to dynamos or alternators, but of late years steam turbines have in most instances replaced them, and are now exclusively used in large generating stations, because of their smaller cost and greater economy in fuel. The size of the turbines may vary from a few thousand horse-power up to about 50,000 horse-power. At the end of last year the central electric stations in the United Kingdom contained plant aggregating $2\frac{3}{4}$ million kilowatts, 79 per cent of which was driven by steam turbines.

Much discussion has taken place as to the most economical size of generating stations, their number, the size of the generating units, and the size of the area to be supplied. On the one hand, a comparatively small number of very large or super stations, instead of a large number of moderate-sized stations dotted over the area, results in a small decrease in the cost of production of the electricity, because in the super-stations larger and slightly more economical engines are employed, while the larger stations permit of higher organisation and more elaborate labour-saving appliances. Further, if in the future the recovery of the by-products of coal should become a

practical realisation as part of the process in the manufacture of the electric current, the larger super-stations present greater facilities than the smaller stations. On the other hand, super-stations involve the transmission of the electricity over greater distances, and consequently greater capital expenditure and cost of maintenance of mains and transmission apparatus, and greater electrical transmission losses, while the larger generating unit takes longer to overhaul or repair, and consequently a larger percentage of spare plant is necessary.

The greatest element in reducing the cost of electricity is the provision of a good load factor; in other words, the utilisation of the generating plant and mains to the greatest extent during the twenty-four hours of each day throughout the year. This is a far more important consideration than the size of the station, and it is secured to the best advantage in most cases by a widespread network of mains, supplying a diversity of consumers and users, each requiring current at different times of the day. The total load of each station being thus an average of the individual loads of a number of consumers is, in general, far less fluctuating than in the case of small generating and distributing systems, which supply principally one class of consumer, a state of affairs that exists in London, for instance, at the present time. It is true there may be exceptional cases, such as at Kilmarnock, where a good load factor may be found in a small area, but in this case the consumers are chiefly mills, which require current for many hours daily.

There is no golden rule to secure cheap electricity. The most favourable size, locality, and number of generating stations in each area can only be arrived at by a close study of the local conditions, but there is no doubt that, generally speaking, to secure cheap electricity a widespread network of mains is in most cases a very important, if not an essential, factor.

The electrification of tramways and suburban railways has been an undoubted success where the volume of traffic has justified a frequent service, and it has been remarkable that where suburban lines have been worked by frequent and fast electrical trains there has resulted a great growth of passenger traffic. The electrification of main line railways would no doubt result in a saving of coal; at the same time, the economical success would largely depend on the broader question as to whether the volume of the traffic would suffice to pay the working expenses, and provide a satisfactory return on the capital.

Municipal and company generating stations have been nearly doubled in capacity during the war to meet the demand from munition works, steel works, chemical works, and for many other purposes. The provision of this increased supply was an enormous help in the production of adequate munitions. At the commencement of the war there were few steel electric furnaces in the country; at the end of last year 117 were at work, producing 20,000 tons of steel per month, consisting chiefly of high-grade ferro alloys used in munitions.

The Future.

The nations who have exerted the most influence in the war have been those who have developed to the greatest extent their resources, their manufactures, and their commerce. As in the war, so in the civilisation of mankind. But, viewing the present trend of development in harnessing water-power and using up the fuel resources of the world for the use and convenience of man, one cannot but realise that, failing new and unexpected discoveries in science, such as the harnessing of the latent molecular and atomic energy in matter, as foreshadowed by Clerk Maxwell, Kelvin, Rutherford, and others, the great position of England cannot be maintained for an indefinite period. At some time more or less remote—long before the exhaustion of our coal—the population will gradually migrate to those countries where the natural sources of energy are the most abundant.

Water-power and Coal.—The amount of available water-power in the British Isles is very small as compared with the total in other countries. According to the latest estimates, the total in the British Isles is under $1\frac{1}{2}$ million horse-power, whereas Canada alone possesses over 20 millions, of which over 2 millions have already been harnessed. In the rest of the British Empire there are upwards of 30 millions, and in the remainder of the world at least 150 millions, so that England herself possesses less than 1 per cent of the water-power of the world. Further, it has been estimated that she only possesses $2\frac{1}{2}$ per cent of the whole coal of the world. To this question I would wish to direct our attention for a few minutes.

I have said that England owes her modern greatness to the early development of her coal. Upon it she must continue to depend almost exclusively for her heat and source of power, including that required for propelling her vast mercantile marine. Nevertheless, she is using up her resources in coal much more rapidly than most other countries are consuming theirs, and long before any near approach to exhaustion is reached her richer seams will have become impoverished, and the cost of mining so much increased that, given cheap transport, it might pay her better to import coal from richer fields of almost limitless extent belonging to foreign countries, and workable at a much lower cost than her own.

Let us endeavour to arrive at some approximate estimate of the economic value of the principal sources of power. The present average value of the royalties on coal in England is about 6d. per ton, but to this must be added the profit derived from mining operations after paying royalties and providing for interest on the capital expended and for its redemption as wasting capital. After consultation with several leading experts in these matters, I have come to the conclusion that about 1s. per ton represents the pre-war market value of coal in the seams in England.

It must, however, be remembered that, in addition, coal has a considerable value as a national asset, for on it depends the prosperity of the great industrial interests of the country, which contribute a large portion of the wealth and revenue. From this point of view the present value of unmined coal seems not to have been sufficiently appreciated in the past, and that in the future it should be better appraised at its true value to the nation.

This question may be viewed from another aspect by making a comparison of the cost of producing a given amount of electrical power from coal and from water-power. Assuming that one horse-power of electrical energy maintained for one year had a pre-war value of £5, and that it requires about eight tons of average coal to produce it, we arrive at the price of 6s. 3d. per ton—*i.e.*, crediting the coal with half the cost. The capital required to mine eight tons of coal a year in England is difficult to estimate, but it may be taken approximately to be £5, and the capital for plant and machinery to convert it into electricity at £10, making a total of £15. In the case of water-power the average capital cost on the above basis is £40, including water rights (though in exceptionally favoured districts much lower costs are recorded).

From these figures it appears that the average capital required to produce electrical power from coal is less than half the amount that is required in the case of water-power. The running costs, however, in connection with water-power are much less than those in respect of coal. Another interesting consideration is that the cost of harnessing all the water-power of the world would be about 8000 millions, or equal to the cost of the war to England.

Dowling has estimated the total coal of the world as over seven million million tons, and whether we appraise it at 1s. or more per ton its present and prospective value is prodigious. For instance, at 6s. 3d. per ton it amounts to nearly one hundred times the cost of the war to all the belligerents.

In some foreign countries the capital cost of mining are far below the figures I have taken, and, as coal is trans-

portable long distances and, generally speaking, electricity is not so at present, therefore it seems probable that capital will in the immediate future flow in increasing quantity to mining operations in foreign countries rather than to the development of, at any rate the more difficult and costly, water-power schemes. When, however, capital becomes more plentiful the lower running costs of water-power will prevail, with the result that water-power will then be rapidly developed.

As to the possible new sources of power, I have already mentioned molecular energy, but there is another alternative which appears to merit attention.

Bore Hole.—In my address to Section B in 1904 I discussed the question of sinking a shaft to a depth of twelve miles, which is about ten times the depth of any shaft in existence. The estimated cost was £5,000,000, and the time required about eighty-five years.

The method of cooling the air-locks to limit the barometric pressure on the miners and other precautions were described, and the project appeared feasible. One essential factor has, however, been queried by some persons. Would the rock at the great depth crush in and destroy the shaft? Subsequent to my address I wrote a letter to *Nature*, suggesting that the question might be tested experimentally. Prof. Frank D. Adams, of McGill University, Montreal, acting on the suggestion, has since carried out exhaustive experiments, published in the *Journal of Geology* for February, 1912, showing that in limestone a depth of fifteen miles is probably practicable, and that in granite a depth of thirty miles might be reached.

Little is at present known of the earth's interior, except by inference from a study of its surface, upturned strata, shallow shafts, the velocity of transmission of seismic disturbances, its rigidity and specific gravity, and it seems reasonable to suggest that some attempt should be made to sink a shaft as deep as may be found practicable and at some locality selected by geologists as the most likely to afford useful information.

When we consider that the estimated cost of sinking a shaft to a depth of twelve miles, at present-day prices, is not much more than the cost of one day of the war to Great Britain alone, the expense seems trivial as compared with the possible knowledge that might be gained by an investigation into this unexplored region of the earth. It might, indeed, prove of inestimable value to Science, and also throw additional light on the internal constitution of the earth in relation to minerals of high specific gravity.

In Italy, at Lardarello, bore holes have been sunk, which discharge large volumes of high-pressure steam, which is being utilised to generate about 10,000 horse-power by turbines. At Solfatara, near Naples, a similar project is on foot to supply power to the great works in the district. It seems, indeed, probable that in volcanic regions a very large amount of power may be, in the future, obtained directly or indirectly by boring into the earth, and that the whole subject merits the most careful consideration.

While on the subject of obtaining power, may I digress for a few moments and describe an interesting phenomenon of a somewhat converse nature—viz., that of intense pressure produced by moderate forces closing up cavities in water.

A Committee was appointed by the Admiralty in 1916 to investigate the cause of the rapid erosion of the propellers of some of the ships doing arduous duties. This was the first time that the problem had been systematically considered. The Committee found that the erosion was due to the intense blows struck upon the blades of the propellers by the nuclei of vacuous cavities closing up against them. Though the pressure bringing the water together was only that of the atmosphere, yet it was proved that at the nucleus 20,000 atmospheres might be produced.

The phenomenon may be described as being analogous to the well-known fact that nearly all the energy of the arm that swings it is concentrated in the tag of a whip. It was shown that when water flowed into a conical tube which had been evacuated a pressure of over 140 tons per square inch was recorded at the apex, which was capable of eroding brass, steel, and in time even the hardest steel. The phenomenon may occur under some conditions in rivers and waterfalls where the velocity exceeds 50 feet per second, and it is probably as great a source of erosion as by the washing down of boulders and pebbles. Then again, when waves beat on a rocky shore, under some conditions, intense hydraulic pressures will occur, quite sufficient of themselves to crush the rock and to open out narrow fissures into caves.

Research.—The whole question of the future resources of the Empire is, I venture to think, one which demands the serious attention of all scientists. It should be attacked in a comprehensive manner, and with that insistence which has been so notable in connection with the efforts of British investigators in the past. In such a task, some people might suggest, we need encouragement and assistance from the Government of the country. Surely we have it. As many here know, a great experimental step towards the practical realisation of Solomon's House as prefigured by Lord Bacon in the *New Atlantis* is being made by the Government at the present time. The inception, constitution, and methods of procedure of the Department, which was constituted in 1915, were fully described by Sir Frank Heath in his paper to the Royal Society of Arts last February, and it was there stated by Lord Crewe that, so far as he knew, this was the only country in which a Government Department of Research existed.

(The Italian Government are now establishing a National Council for Research, and a Bill is before the French Chamber for the establishment of a National Office of Scientific, Industrial, and Agricultural Research and Inventions).

It is obvious that the work of a Department of this kind must be one of gradual development with small beginnings, in order that it may be sound and lasting. The work commenced by assisting a number of researches conducted by scientific and professional societies which were languishing as a result of the war, and grants were also made to the National Physical Laboratory and to the Central School of Pottery at Stoke-on-Trent. The grants for investigation and research for the year 1916-17 totalled £11,055, and for the present year are anticipated to be £93,570. The total income of the National Physical Laboratory in 1913-14 was £43,713, and owing to the great enlargement of the Laboratory the total estimate of the Research Department for this service during the current year is £154,650.

Another important part of the work of the Department has been to foster and to aid financially Associations of the trades for the purpose of research. Nine of these Associations are already at work; eight more are approved, and will probably be at work within the next two months; and another twelve are in the earlier stage of formation. There are also signs of great increase of research by individual factories. Whether this is due to the indirect influence of the Research Department or to a change in public opinion and a more general recognition of the importance of scientific industrial research it is difficult to say.

The possibility of the uncontrolled use on the part of a nation of the power which Science has placed within its reach is so great a menace to civilisation that the ardent wish of all reasonable people is to possess some radical means of prevention through the establishment of some form of wide and powerful control. (For instance, it might some day be discovered how to liberate instantaneously the energy in radium, and radium contains 2½ million times the energy of the same weight of T.N.T.). Has not Science forged the remedy, by making the world a smaller arena for the activities of civilisation, by reducing distance in terms of time? Alliances and unions, which have successfully controlled and stimulated republics of heterogeneous races during the last century,

will therefore have become possible on a wider and grander scale, thus uniting all civilised nations in a great League to maintain order, security, and freedom for every individual and for every State and nation liberty to devote their energies to the controlling of the great forces of Nature for the use and convenience of man, instead of applying them to the killing of each other.

Many of us remember the President's Banner at the Manchester Meeting in 1915, where Science is allegorically represented by a sorrowful figure covering her eyes from the sight of the guns in the foreground. This year Science is represented in her more joyful mien, encouraging the arts and industries. It is to be sincerely hoped that the future will justify our present optimism.

HOW THE NITROGEN PROBLEM HAS BEEN SOLVED.*

By HENRY JERMAIN MAUDE CREIGHTON, Department of Chemistry, Swarthmore College, Member of the Institute.

(Continued from p. 138.)

The Technical Oxidation of Ammonia to Nitric Oxide.

Although considerable progress has been made during the past few years in the technical oxidation of ammonia, but little detailed information is available regarding the

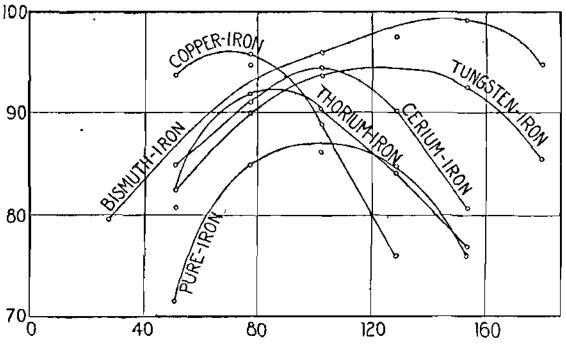

Fig. 15.

Velocity of Passage of Gas Mixture in Litres per Hour (at Room Temperature) per cc. of Free Space in Catalytic Chamber. Each cc. Free Space = 20 cm.² of Catalyst Surface.

various processes that have been developed. These processes conform to the following three types:—

1. Oxidation by means of a platinum plug (Ostwald process);
2. Oxidation by means of an electrically heated platinum gauze;
3. Oxidation by means of base metal catalysts.

The principle of the first type of processes is that originally patented by Ostwald, but the catalyser has been considerably modified, although it consists of metallic platinum. Little information regarding the details of the preparation of the catalyser is available, but it is known to have a very small cross-section. It is placed at the end of a 60-mm. tube. The ammonia-air mixture is preheated before reaching the catalyser, by utilising the heat produced by the oxidation. No external heat is necessary. It is stated that the reaction when once started continues without interruption for weeks. The yield is good, averaging 90 per cent, but the temperature regulation is more difficult than in the second type of processes, in which electrical heating is used.

The second type of processes possesses many advantages over processes of the Ostwald type, and is rapidly increasing in favour. A diagram (*Chem. Met. Eng.*, 1916, xiv., 425) of a catalyser used in a process (Frank and Caro's) of this second type is shown in Fig. 16. The catalyst is 80—100 mesh platinum gauze electrically heated to 700° C. At the bottom of the catalyser the air enters on one side and the ammonia on the other. Before these gases mix, they pass through gauze collars, as indicated. The diameters of these collars are selected so that the best mixture for oxidation will be obtained. For further adjustment a valve is placed in each pipe-line. The gases are mixed by a revolving aluminium fan, after which they pass through the heated platinum gauze (no heat exchange taking place), where an almost quantitative conversion of the ammonia to nitric oxide occurs. The lower half of the casting surrounding the glowing platinum gauze is cooled by cold water, in order to prevent as far as possible any decomposition of the ammonia by

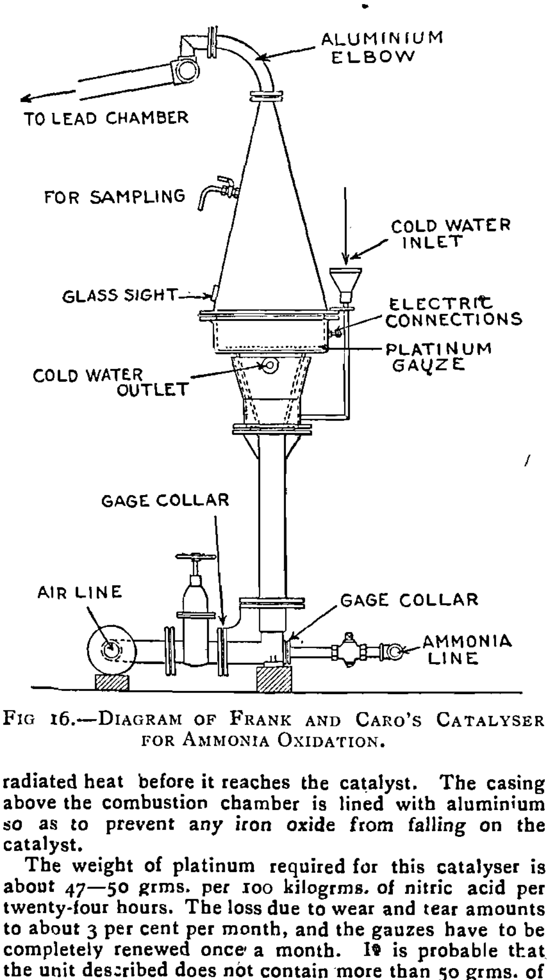

Fig 16.—Diagram of Frank and Caro's Catalyser for Ammonia Oxidation.

radiated heat before it reaches the catalyst. The casing above the combustion chamber is lined with aluminium so as to prevent any iron oxide from falling on the catalyst.

The weight of platinum required for this catalyser is about 47—50 grms. per 100 kilogrms. of nitric acid per twenty-four hours. The loss due to wear and tear amounts to about 3 per cent per month, and the gauzes have to be completely renewed once a month. It is probable that the unit described does not contain more than 50 grms. of platinum.

To keep the gauze heated 135 amperes supplied at 25 volts, viz., 3375 kilowatts, are required. If, therefore, the catalyser produces 100 kilogrms. of nitric acid per day the electrical energy consumed amounts to 0·81 kilowatt hours per kilogrm. of nitric acid.

A catalyser in use in England has recently been described by Partington (*Journ. Soc. Chem. Ind.*, 1918, xxxvii., 337 R). One form of this is shown in Fig. 17. This catalyser consists of two aluminium cones, con-

* From the *Journal of the Franklin Institute*, April, May, and June, 1919

nected by three rectangular aluminium body pieces having a cross-section of 4 in by 6 in. In the three lower junctions perforated baffle plates are inserted, while the junction between the top segment of the body and the upper cone is occupied by the catalyst frame. The ammonia-air mixture enters at the bottom and the nitrous gases leave at the top, through aluminium tubes having an internal diameter of 2 in. The upper cone is provided with a mica window for the inspection of the catalyst. This consists of one or more platinum gauzes which are stretched across the catalyser at right angles to the gas flow. The gauzes, having 80 meshes to the inch, are made of pure platinum wire 0·0025 in. in diameter, and weigh about 50 grms. per square foot. The life of the gauze is about three months. New gauzes require to be used for a few hours before attaining their full catalytic activity.

The ignition temperature is attained by heating the catalyst, either electrically or by means of a non-luminous

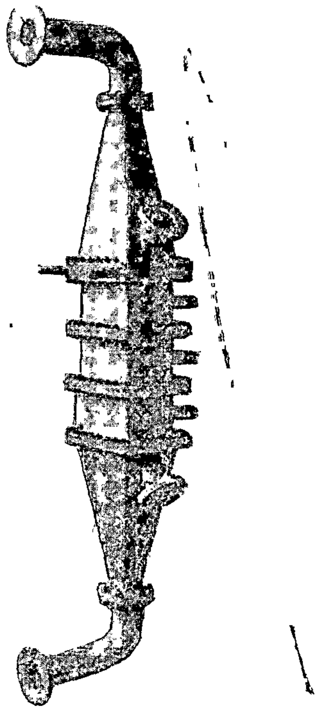

Fig. 17.—Catalyser for Ammonia Oxidation.

gas flame, but once the reaction commences the heat developed is sufficient to maintain the gauze at red heat and conversion proceeds without interruption.

When working under established conditions with this catalyser, a yield of one and one-half tons of nitric acid per square foot of catalyst area per twenty-four hours has been regularly attained, with a conversion efficiency of 95 per cent. Without the application of external heat the efficiency is about 85 per cent.

The first ammonia oxidation plant established in the United States on a commercial scale was installed at the Ammo-Phos Works of the American Cyanamid Company, at Warners, New Jersey, in July, 1916. The catalyser units at that time had a conversion capacity of 14 pounds of nitric acid per hour, but improvements in design and methods have since raised this figure to 40 pounds. The catalyst is heated electrically and consists of a single fine platinum gauze having an area of about two square feet. In this catalyser the gas mixture passes downwards through the gauze. The high efficiency obtained with this catalyser is illustrated by a record for the week July 13 to 19, 1918, shown in Table XI.

At the United States Government Nitrate Plant at Muscle Shoals nearly 700 catalysers have been installed during the past year. Each of these consists of an aluminium box, having a cross-section of 14 in. × 28 in. and a height of 5 feet. At the base a sheet of platinum gauze weighing 143 grms. is stretched at right angles to the gas flow. The gauge has 80 meshes to the inch and is made of wire 0·003 in. in diameter. Each catalyser has an 8 kilowatt transformer, and is operated with 375 amperes at 21 volts.

At the Semet-Solvay Company's small plant, in Syracuse, N.Y., electrically heated, multiple platinum gauzes are employed.

Table XI.—*Catalyser No.* 5.

Date.	Hour.	Conversion efficiency. Per cent.
July 13	2.35 a.m.	96·2
July 13	8.40 a.m.	98·5
July 13	5.20 p.m.	93·1
July 13	11.50 p.m.	96·0
July 14	5.50 a.m.	97·4
July 14	5.10 p.m.	94·8
July 15	10.35 a.m.	95·0
July 15	5.15 p.m.	95·8
July 16	1.50 a.m.	95·4
July 16	11.20 a.m.	95·4
July 17	1.10 a.m.	92·1
July 17	1.00 p.m.	92·3
July 18	12.50 a.m.	93·4
July 18	10.55 a.m.	92·6
July 18	8.00 p.m.	91·9
July 19	9.50 a.m.	93·6
Average for week		94·5

Production, Energy Requirements, Costs.

Although ammonia oxidation plants are in operation in the United States, England, France, Germany, Italy, and Russia, no information is available regarding the world's annual production of nitric acid from ammonia. It had been estimated that in the spring of this year in the United States the producing rate of nitric acid from ammonia, obtained by the fixation of atmospheric nitrogen, would be about 225,000 tons 100 per cent acid per annum. Owing to the signing of the armistice, however, it is probable that the Government plant at Muscle Shoals will probably cease operation for a time. With the closing of this plant there will be no nitric acid produced in this country by the oxidation of ammonia, with the exception of the small amount that is prepared from cyanamide ammonia at the Ammo-Phos Works of the American Cyanamid Company at Warners, N.J., for operating their 50,000 ton sulphuric acid plant, and a small quantity produced at the works of the Semet-Solvay Company at Syracuse, N.Y.

The energy required for the production of nitric acid from ammonia is small. It consists of the electrical energy used in heating the catalyst, and the energy employed in operating the blowers which force the gas mixture through the catalyser and that used in the absorption of the nitrous gases and in the concentration of the dilute nitric acid.

Owing to the high velocity of the ammonia-air mixture through the catalyser a comparatively large amount of ammonia can be oxidised with a relatively small catalyser, and since the energy requirements are small the conversion cost will be low. Estimates of this cost vary considerably, but it is probable, under normal conditions, that it is somewhat under one cent per pound of nitric acid, in the form of 53 per cent acid. The total cost of nitric acid (93 per cent) by the oxidation method is probably a little less than three cents per pound.

From a financial standpoint the production of nitric acid by the oxidation of ammonia can compete successfully with its production by the retort process from sodium nitrate, as the cost of conversion is about the same in both processes. Moreover, since sodium nitrate and ammonium sulphate have sold in the past at the same price per pound of nitrogen, ammonia is the cheaper form of nitrogen by the amount of sulphuric acid required to convert it into the sulphate. This, therefore, will make a difference of 15 to 20 per cent in the cost of nitric acid in favour of the oxidation of ammonia.

(To be continued).

VACUUM ARC SPECTRA OF VARIOUS ELEMENTS IN THE EXTREME ULTRA VIOLET.*

By Prof. J. C. McLENNAN, F.R.S.; D. S AINSLIE, M.A.; and D. S. FULLER, M.A., University of Toronto.

(Concluded from p. 116).

11. *Cadmium.*—The results obtained with the cadmium arc below λ 2000 A are given in Table XII. This Table also includes the wave-lengths of the spark spectrum of cadmium as given by Saunders, McLennan and Edwards (*Phil. Mag.*, 1915. xxx., 695), Bloch, and Takamine and Nitta. The wave-lengths of the cadmium vacuum arc spectrum, as measured by Wolff, are also given.

Between λ 2000 A and λ 1840 A it will be seen by reference to Table XII. that practically all of the wave-lengths observed by us with the vacuum arc are included in the wave-lengths given for the spark spectrum by McLennan and Edwards, Bloch, and Takamine and Nitta.

Below λ 1840 A the only results recorded are those found by Saunders and by Wolff, and the wave-lengths given by them, with the exception of the last three of Wolff's, are in good agreement with our measurements. Our list of wave-lengths, it will be seen, contributes a number of additions to the spectrum of cadmium as hitherto known.

The work with cadmium was done without the gas comparison spectrum. As a consequence, the measurements are not quite so accurate as the work with the other substances, and may contain a few lines belonging to the secondary gas spectrum. As far as possible, however, such lines were eliminated by comparing the wave-lengths obtained in the spectrum with the wave-lengths of the strong lines in the hydrogen spectrum.

5. *Summary of Results.*

1. The vacuum arc spectra of copper, zinc, aluminium, carbon, thallium, tin, lead, iron, cobalt, nickel, and cadmium, have been investigated down to λ 1400 A. The measurements for the vacuum arc spectra of copper, zinc, cadmium, and aluminium are well covered by the results for the spark spectrum of these metals, as obtained by previous workers.

2. For tin, lead, and thallium, Saunders has given measurements down to λ 1700 A, and the results of his work have been found to correspond fairly well with our results. Below the region covered by Saunders' work many new lines have been observed and measured.

3. The measurements for the vacuum arc spectra of iron, cobalt, nickel, and carbon appear to be the first obtained for the arc spectra of these substances in the Schumann region. For these spectra nearly all the measurements down to λ 1850 A as given in our work are covered by previous work on spark spectra of these metals, but in the region between λ 1850 A and λ 1400 A several new lines were photographed and measured.

* From the *Proceedings of the Royal Society*, A, xcv., 316.

TABLE XII.

	Vacuum arc.		Spark and arc.	Spark.		
Intensity.	The Authors. λ (A).	Wolff λ (A).	Saunders. λ (A).	McLennan and Edwards. λ (A).	Bloch. λ (A).	T. and N. λ (A).
1	1393·5	1993·07		1995·1	1994·78	1994·8
1	1988·0		1987·87	1989·2		1989·1
				1977·1	1976·85	1977·4
				1970·4		1975·0
						1965·8
1	1966·0			1965·4	1965·44	1965·3
						1662·4
						1961·6
					1956·81	1956·7
1	1946·9			1945·6		
					1943·85	1944·1
		1942·29		1942·9	1942·61	1942·5
4	1940·0			1939·2	1938·91	1939·2
2*	1932·5					
						1930·4
				1921·9	1921·55	1921·4
				1919·6	1919·30	1919·6
					1914·50	1914·4
			1903·37			
				1901·1	1900·70	1900·6
				1899·2	1898·27	
1*	1894·5					
					1896·64	1896·7
					1887·78	
				1883·1	1884·08	1884·2
				1877·8		
1	1874·5		1874·06	1873·8	1873·37	1873·2
1*	1871·0				1867·73	1867·7
					1865·34	1865·3
			1856·62	1856·4	1856·10	
2	1855·5		1855·83	1854·8	1855·32	1855·2
				1850·6		1850·7
4	1846·5		1844·58	1844·1		1843·7
1	1827·0					
3	1808·0					
			1793·06			
4	1790·5		1789·04			
	1773·0		1772·89			
			1768·54			
			1747·77			
2	1745·5					
4	1728·0					
			1721·76			
3	1711·0	1710·5				
2	1706·5		1707·04			
2*	1704·0					
		1688·58				
		1682·12				
10	1668·5	1669·29				
1*	1656·5					
2	1647·5	1647·78				
		1571·4				
		1537·83				
1	1526·5	1526·85				
		1469·39				
		1440·18				
		1423·23				

* Not given in previous lists.

THE Board of Trade have received a large number of replies from local authorities accepting their invitation to form local committees under the Profiteering Act, and many chairmen of County Councils have already submitted names of the persons selected by representative county meetings for consideration as members of the appeal tribunals. The regulations for both local committees and appeal tribunals are in the press and will be circulated to the local authorities immediately.

METALLIC COATINGS FOR THE RUST-PROOFING OF IRON AND STEEL.*

Steel is protected against corrosion in a great variety of ways, including metallic and related coatings, paints, lacquers, varnishes, enamels, &c. The Circular deals with the various types of metallic coatings, including those closely related in their nature and method of production (oxide and similar coatings). The methods of application and characteristics of the different metal coatings are discussed, and it is shown that zinc, because of its electro-positive nature with respect to iron, is the metal to be relied upon when protection against corrosion is the prime consideration. Other considerations, *e.g.*, freedom from toxic effects, *e.g.*, for food containers, often lead to the choice of some metal other than zinc for a coating.

The structure and uniformity of distribution of the different classes of zinc coatings are discussed, and their bearing upon the behaviour in service is pointed out. Of the various methods which are used for the testing of coated materials, the "salt spray" test is by far the most satisfactory. The articles to be tested are exposed to a fine mist of a saturated salt solution, and the length of time that they successively withstand this severe exposure is a fair index of the service life that may be expected for the specimen. This test while not entirely satisfactory is the best which has yet been suggested.

A series of recommendations concerning the choice of protective metallic coatings for various types of works is given, together with a good working bibliography of the subject.

* U.S. Bureau of Standards, Circular No. 80. From the *Journal of the Franklin Institute*, August, 1919.

UNIVERSITY OF LIVERPOOL.

The arrangements for Session 1919-20 are here given. (See last issue, p. 127).

Professor of Inorganic Chemistry—E. C. C. Baly, C.B.E., M.Sc., F.R.S.

Professor of Physical Chemistry—W. C. McC. Lewis, M.A., Ph.D.

Professor of Bio-chemistry—W. Ramsden, M.A., D.M.

Professor of Organic Chemistry—R. Robinson, D.Sc.

Assistant Professor in Public Health Chemistry—W. H Roberts, M.Sc.

Lecturer on Analytical Chemistry—J. Smeath Thomas, D.Sc.

Lecturer in Applied Organic Chemistry—Francis W. Kay, M.Sc., Ph.D.

Lecturer in Public Health Chemistry—E. Gabriel Jones, M.Sc.

Assistant Lecturers and Demonstrators—D. M. Edwards, B.Sc.; F. C. Guthrie, M.A.; E. G. Tryhorn, M.Sc.; W. Doran, B.Sc.; R. O. Griffith, M.Sc.; W. J. Shutt, B Sc.

Lecture Assistant—H. H. Froysell, A.I.C.

The Session commences early in October.

The Classes meet the requirements of candidates for the Ordinary B.Sc. Degree, for Chemistry Honours, or for the M.Sc., Ph.D., or D.Sc. Degree in the University of Liverpool; for Degrees in Medicine of Liverpool; for the Pharmaceutical, Veterinary, Dental, and Public Health Diplomas; and for those studying Chemistry as a preparation for professional, technical, or commercial life. The Classes qualify for the Associateship of the Institute of Chemistry and other Examination Boards.

Lecture Courses.

A. General Introductory Course, including the principles of Organic and Physical Chemistry. Three Terms.
Course B.—Inorganic Chemistry.
Course C.—Inorganic Chemistry (Honours Course).
Course D.—Organic Chemistry.
Course E.—Organic (Honours).
Course F.—Physical Chemistry.
Course G.—Honours Physical Chemistry.
Course H.—Applied Inorganic Chemistry.
Course J.—Metallurgy.
Course K.—Applied Organic Chemistry.
Course L1.—Electro-chemistry. L3.—Colloids.
Also Honours Courses in Bio-chemistry.

Fees.—Any course of lectures prescribed for examination, £4 10s. Class A., lectures and practical, £8 5s. Laboratory work: First year final, £6; Second year final, £9. Composition fees: Intermediate; Mathematics, Physics, and Chemistry, £20; First year final, £21; Second year final, £21. Chemistry, Honours, first year, £21; second year, £21. Biochemistry, Honours, £21.

Research students carrying out research work pay a fee of £3 per annum.

The Inorganic and Organic Chemical Laboratories provide accommodation for every kind of work and research in inorganic and organic chemistry and in metallurgy. There is also a laboratory devoted to spectroscopic work and research.

The Muspratt Laboratories of Physical Chemistry and Electro-chemistry adjoin the main chemistry buildings, and, owing to their full equipment, offer every opportunity for all manner of work and research in these subjects.

The Bio-chemical Laboratory is also separately housed, and provides facilities for work and research.

Students desirous of gaining a thorough theoretical and practical acquaintance with Technical Chemistry, or who intend to adopt Chemical work as a profession, must devote three or four years to special study, for which a full curriculum is provided.

D.P.H. Course (see special syllabus).

Course for Dental Degree and Diploma (see special syllabus).

The Final Examination for the Associateship of the Institute of Chemistry may be taken after the third year. Those students who have taken the Ordinary Degree of B.Sc. may pass the M.Sc. Exam. in any subsequent year.

The Sir John Willox Scholarship of £50 per annum, tenable for two years, will be competed for in December, 1919, on an Examination in subjects which are included in the first two and a half years of the above curriculum. Candidates should send in their names to the Registrar not later than November 15. The Campbell Brown and Sheridan Muspratt Scholarships, on similar lines, are open for competition. Other Scholarships, Entrance Scholarships, and Free Studentships are also available to Students. Regulations as to these may be obtained from the Registrar.

NOTES.

The Birmingham Public Libraries Committee have opened a Commercial Library, with the object of providing business men with a ready means of finding markets for their goods. The new department was recently opened by the Rt. Hon. The Lord Mayor of Birminghan and contains some 2000 volumes of commercial importance as well as all trade catalogues, atlases, telegraph codes, directories, technical journals, and parliamentary papers, as usual. The idea is quite a new one, and is likely to be found extremely useful, and the example might be followed with advantage in other towns.

Method of Growing Large Perfect Crystals.—Seed crystals are introduced into a nearly saturated solution of the salt, and this mother-liquor is then cooled until it is very slightly supersaturated. The containing vessel is then immersed in a water-bath, and the liquid maintained in a state of very slight supersaturation by very slowly cooling the solution. This is effected by means of a delicate and very accurately adjusted thermostat, by

means of which the temperature of the liquid in the bath can be regulated and maintained within very narrow limits. The seed crystals then grow into perfectly-formed clear crystals as long as the state of supersaturation is maintained. The saturated solution may be made conveniently between 30—40° C. After removing the excess of salt it is warmed to 7° or 8° C. above the saturation temperature and filtered. It is not allowed to fall to less than 4·5° above its saturation temperature. The seed crystals are placed in a jar and the solution poured in. The jar is at one covered with a glass plate and immersed in a large water bath. The temperature is allowed to fall to practically the saturation point as fast as the bath cools. Then, by means of the thermostat, the rate of cooling is controlled and the temperature allowed to drop only at the rate of about 0·1° C. until the crystals have grown notably. Then the temperature is allowed to fall 0·2° C. in twenty-four hours. When the crystals are about an inch long, the rate of decrease of temperature is increased to 0·3° or 0·4° per diem, and finally to 0·5—0·6° C. When the mother-liquor has cooled to room temperature the crystals are taken out and dried by wiping with a soft cloth. The method requires considerable time and patience. The least fluctuation either way in the gradual fall of the temperature will vitiate the results. If carefully carried out, absolutely perfect crystals, quite transparent and free from flaws or secondary growths, may be obtained. Photographs of excellent, transparent, perfect crystals of Rochelle salt, between two and three inches in length, obtained in this manner, are given.—R. W. Moore, *Journal of the American Chemical Society*, 1919, xli., 1060.

The *Technical Supplement* and the review of the foreign press formerly issued by the General Staff of the War Office, but discontinued last month, will now appear under the name of the *Technical Review*. It will be conducted by its original Editor and with the same organisation and technical staff. The *Technical Review* will continue to perform, on an even broader basis, its valuable and important function of reviewing and digesting the Technical Press of the whole world, British, American, and Foreign, for the benefit of the engineering and manufacturing community—a function which obviously is equally serviceable to the technical press itself.

The statement which has appeared in the press as to the control of the Department of Overseas Trade is unauthorised and incorrect. The Department remains under the joint control of the Foreign Office and the Board of Trade, and any arrangements made as regards housing will not affect this joint control.

Sir John Cass Technical Institute.—The new session of the Institute, Jewry Street, Aldgate, E.C. 3, will commence on Thursday, September 25. The work of the Institute is specially devoted to technical training in Chemistry, Metallurgy, and Physics, and in the Artistic Crafts. Full details of the courses are given in the Syllabus of the Institute, which can be had upon application at the Office at any time or by letter to the Principal. The Principal and Heads of Departments will attend at the Institute to interview students on Tuesday, September 23, and Wednesday, September 24, from 7 to 9 p.m.

Training in Chemical Industry.—A course of training in Industrial Chemistry is to be started at the Northern Polytechnic Institute, Holloway, N. 7, on September 22. This course is open to the general public, and is admirably suited to the requirements of demobilised men who desire to take up positions as analytical and work chemists. It is exceptionally interesting to note that in addition to the usual training in chemistry and allied subjects, glass working, instrument making, and plumbing also receive attention. As it is frequently the lot of the works chemist to undertake or supervise operations which involve applications of the latter subjects, their inclusion in this curriculum is a feature which renders the course particularly attractive. Detailed information may be obtained by writing to, or calling to see, the Principal.

Assistant Chemist (21) seeks Situation in any branch of Chemistry. Sound Technical training. Five years' Analytical experience in Feeding-stuffs, Fertilisers, T.N.T., Acids, Coal-tar Products, Sugar, Starch Products, &c.—Address, H. E. J., Chemical News Office, 16, Newcastle Street, Farringdon Street London, E.C.4.

Chemist, three years' experience in large Tar Products Works before taking active service, now demobilised, desires Employment in London or the Provinces.—Address, T. T., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Chemist, 26, demobilised, B.Sc. Hons. (Lond.), and knowledge of Bacteriology, seeks Employment in London.—Address, "C 26," Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Inter. B Sc. (Boy, 18) desires Employment as Laboratory Assistant in any branch of Chemistry. North London preferred.—Address, A. F., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Young Chemist (Inter. B.Sc.), ex-service man, desires a Position as Assistant in Laboratory or Works Factory. Good references.—Address, Y. C., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

Youth (17), with practical knowledge of Analytical and Organic Chemistry, desires Position in Laboratory as Assistant.—Address, J. C , 1, Phœnix Lodge Mansions, Hammersmith.

Wanted, ANALYTICAL BALANCES, New or Second-hand, in good condition; 200 grm. to one tenth mgrm.—Offers to "Balances," Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

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THE CHEMICAL NEWS.

VOL. CXIX., No. 3102.

ADDRESS TO THE CHEMICAL SECTION OF THE BRITISH ASSOCIATION.

BOURNEMOUTH, 1919.

By Prof. P. PHILLIPS BEDSON, D.Sc., President of the Section.

IN again taking up the work of this Section, after an interval of three years, a discontinuity without parallel in the annals of the Association, it is natural that our thoughts should turn to the past, and in so doing we are reminded of the gaps in the ranks of those who were accustomed to contribute to the work of our Section. In 1916 we met under a shadow caused by the death of Sir W. Ramsay, whose genius has added in so many ways to our science. And to-day we have to record the loss of one who in his long life contributed in a variety of ways to the advancement of chemistry, and to whom we owe an addition to the number of elementary substances in the discovery of thallium, one of the early fruits of the use of the spectroscope. The chemistry of the rare earths has been especially illumined by the researches of Sir William Crookes. With physicists we would join in a tribute to the memory of Lord Rayleigh, amongst whose experimental researches is one of special interest to chemists—namely, the revelation of the existence of argon, of which discovery Sir J. J. Thomson has recently written that it was not made "by a happy accident, or by the application of new and more powerful methods than those at the disposal of his predecessors, but by that of the oldest of chemical methods—the use of the balance."

In this connection it is but right that, despite the feelings engendered by the war, I should refer to the passing of two great chemists—Baeyer and Fischer. The former died some two years ago, and the latter within the last few months. Each of them has advanced by his experimental researches the progress of organic chemistry, and has brought illumination into many of the obscure departments of this branch of science. The field of investigation latterly cultivated by Fischer has revived an interest in the "vital" side of organic chemistry as distinguished from the study of the chemistry of the carbon compounds. Moreover, there are many British chemists, amongst them some of the most distinguished, who, as students, received guidance and inspiration from the teaching of Baeyer or of Fischer, and with them we gratefully acknowledge our indebtedness.

Fifty years ago Mendeléeff communicated to the Russian Chemical Society a memoir which has exercised a profound influence on chemical philosophy, and continues to serve as a guide in the interpretation of research and speculations on the nature of the elements. Without entering on the somewhat vexed question as to whom should be assigned the credit of the discovery of the Periodic Law, I trust I shall not be considered unmindful of the claims of Newlands, by adopting the traditional history, and, as is usual, associate this discovery with the name of Mendeléeff, and consequently we may look on this year as the jubilee of the Periodic Law. Although there is already abundant special literature dealing with this subject, and the periodic system has been assimilated into the teaching of the science and is dealt with in the text-books of chemistry, in some of which it forms the basis of the system employed in the exposition of the facts and theories of inorganic chemistry, still it appeared to me that I might utilise this as an opportunity of passing in brief review some of the features of the rise and development of the "Periodic Law."

The memoir, made known to the non-Russian reader by the abstract in German, shows the principle of periodicity—viz., the recurrence of similar properties at regular intervals with increase in the magnitude of atomic weights, the possibility of utilising the atomic weights as a basis of the classification of the elements, the necessity for the revision of the values thus assigned to the atomic weights of certain elements, and finally that the scheme demanded for its completeness the existence of many new elements.

The later writings of Mendeléeff contain the mode of tabulating the elements in the form usually adopted in chemical text-books, portraying the principle of periodicity and showing the grouping of the elements into natural families. But undoubtedly the clearest demonstration of the association between the atomic weights and the physical properties of the elements is that exhibited by the curve of atomic weights and atomic volumes, which is an outcome of the independent studies of these relationships by Lothar Meyer, and, as is well known, shows the members of the natural families of elements occupying corresponding positions on the curve. This curve, with its undulations, corresponding to the series of the elements, has contributed to impress on the mind of the student the relationship between the properties of the elements and their atomic weights, and may have exercised an influence in drawing attention to these relationships which the attempts of the earlier workers in this field were not successful in doing.

Mendeléeff's Table of the Elements was just beginning to figure in the teaching of chemistry in my undergraduate days, and, together with the speculations underlying it, aroused considerable interest and proved an incentive and inspiration for experimental inquiry. Foremost in this country amongst those who by their writings have contributed to spread a knowledge of Mendeléeff's speculations was my fellow student, Carnelley. His experimental investigations added materially to our knowledge and definition of the physical properties of elements and compounds, which further emphasised the periodicity in the relation of the atomic weights to the properties of the elements, and have provided data from which curves, resembling in contour the atomic volume curve, have been set up.

A valuable guide in fixing the atomic weights of the elements has been the specific heat which, as the discovery of Dulong and Petit showed a hundred years ago, varies in the case of solid elementary bodies inversely with their atomic weights; or, as is more usually expressed, the solid elements have the same atomic heat. The investigation of the exceptions to this empirical rule brought out the fact that the specific heat is influenced by temperatures, and the study of the influence of low temperature led Sir James Dewar to the discovery that at about 50° Absolute the atomic heats of the elements are a periodic function of the atomic weights. Further, the graphic representation of this relation gives a curve very similar in its course to that of the atomic volume curve. So that the specific heat is another of the physical properties to fit into the periodic scheme.

The necessity for a revision of the atomic weights of certain elements, as pointed out by Mendeléeff, has induced several workers to direct their energies to the solution of the problems indicated, so that in our present-day tables many of the anomalies of position and sequence which existed in the earlier schemes have disappeared. Tellurium has still resisted all attempts to bring it into order, with an atomic weight less than that of iodine, which its association with sulphur and selenium demands. The interesting attempts to decompound tellurium have so far remained unfruitful.

But undoubtedly the most fascinating feature of the periodic system is that "it allows the discovery of many new elements to be foreseen." This and the manner in

which Mendeléeff, in full conviction of the truth of the "Periodic Law," boldly assigned properties to those elements required to fill the blank spaces in the table of the elements, and the verification within twenty years in three instances of these prophetic specifications have contributed to the recognition and firm establishment of the "Periodic Law" as an article of belief in chemical philosophy, and to make it the mainspring and inspiration of the greater part of modern inorganic research.

The discovery of argon, the announcement of which formed a notable feature in the proceedings of the Association at the Oxford meeting in 1894, and the recognition in it of an element with an atomic weight of 40, raised doubts in the minds of some as to the validity of the scheme of the elements based upon the Periodic Law. It was indeed a time of testing the faith. The suggestion that argon would prove to be a modified form of nitrogen was brushed aside by the incontrovertible establishment of it as an element, endowed only with specific physical properties and distinguished from all known elements by its lack of any of those activities which characterise the remaining elements. But argon was not destined to enjoy a splendid isolation for long. The researches of Sir W. Ramsay soon brought helium to earth, and he and his colleagues provided a number of companions for argon. So, in a very short period, was recognised the existence of a group of gaseous elements forming a natural family, whose molecules are monatomic, the members of which are distinguishable by their spectra and atomic weights, but are all in agreement in their unreadiness to take part in any chemical change. This inertness or non-valence provided a simple means of reconciliation with the periodic scheme of the elements, as all that was required was simply to add to the eight groups of the table of elements a zero group containing helium, neon, argon, krypton, and xenon, and with niton, the emanation from radium, as a recent addition. If we are to accept Mendeléeff's suggestion, the zero group should contain a member lighter than hydrogen, in Series I., and in a zero series a still lighter representative of the elements of the zero group, which he has postulated as the "ether" of the physicist.

Thus the discovery of argon has formed a starting-point in the development and a justification of the natural system of the elements, but it still remains, to make the tabulation complete, that provision should be made for the accommodation of the rare earths. The paper published by Werner in 1905, under the title "A Contribution to the Development of the Periodic System," shows how this can be satisfactorily accomplished.

The elements of the argon group form a valuable extension to the periodic system, and the knowledge acquired in the investigation of these substances has proved serviceable in the solution of problems in the realms of science and of industry. The knowledge of the properties and behaviour of helium was destined soon to play a part in the solution of the riddle of the radio-active elements, whilst it is specially noteworthy that argon, the "idle one," should have been pressed into industrial service.

This fact suggests the thought that idleness has its uses, and at the present time how satisfactory would it be were we able to find useful application for a quality which appears to be plentifully and widely distributed in this country.

The history of helium is still more astonishing, for not until thirty years after its existence had been surmised from spectroscopic observations of the sun was this element found to have a terrestrial existence, and now, as one of the achievements of science during the war, we may look on its production in bulk as a commercial proposition. Moreover, we are told "that the advances made in the production of helium warrant the opinion that, had the war continued after November 11, 1918, supplies of helium at the rate of 2,000,000 cubic feet per month would have been produced within the Empire and the United States, and helium-filled aircraft would have been in service" (*Nature*, July 17, 1919).

Some of the speculations that the periodic system of the elements has given rise to have been the subjects of communications to this Section.

At the Aberdeen meeting Carnelley, whom I have already mentioned as an ardent worker in this field, gave an account of a scheme based on the conception that the elements are composite, having relations similar to those exhibited by the paraffin hydrocarbons and the isologous series of radicles derived from them. He regarded the elements, other than hydrogen, as made up of two simple elements, A and B. A he identified with carbon, with the atomic weight of 12, and B was assumed to have a negative atomic weight of 2.

In the following year, at Birmingham, Sir W. Crookes devoted his Address in this Section to an exposition of his ideas of the "Genesis of the Elements," a subject to which he on many subsequent occasions returned, and amplified in the light of recent discovery. The process of evolution of the elements from a primal "protyle" is depicted as taking place in cycle after cycle, in each cycle the "unknown formative cause" scattering along its journey clusters of particles corresponding to the atoms of the "elements," forming in this way a series such as that beginning with hydrogen and ending with chlorine; a repetition of the movement under somewhat altered conditions giving rise to a series of similarly related elements, and thus homology, which is shown by the members of the natural families, is provided for.

The investigations of Sir J. J. Thomson on the discharge of electricity through gases have established the divisibility of the atoms, and in his "Corpuscular Theory of Matter" he has given us conceptions of how atoms may be constituted to provide a series so related that they reflect, if not reproduce, many of the chemical characters of the elements and their periodic relation to atomic weights.

With the discovery of radium and its remarkable properties we have been brought in contact with an element undreamt of in our philosophy. The interpretation of the results of the investigation of this element has called for drastic changes in our conception of an element. The pursuit of the researches of the radio-active elements, guided by the theory of the spontaneously disintegrating atom propounded by Rutherford and Soddy, has served to reveal facts which lend a special emphasis to many passages in the Address of Sir W. Crookes to which I have already referred.

For instance, the passage in which he said:—"Should it not sometimes strike us, chemists of the present day, that after all we are in a position unpleasantly akin to that of our forerunners, the alchemists of the Middle Ages? The necromancers of a time long past did not, indeed, draw so sharp a line as do we between bodies simple and compound; yet their life-task was devoted to the formation of new combinations, and to the attempt to transmute bodies which we commonly consider as simple and ultimate—that is, the metals. In the department of synthesis they achieved very considerable successes; in the transmutation of metals their failure is a matter of history."

Or again, when he propounded the question, "Is there, then, in the first place, any direct evidence of the transmutation of any supposed 'element' of our existing list into another, or of its resolution into anything simpler?" —a question to which he, Sir William Crookes, was at that time forced to reply in the negative, whereas to-day many instances might be cited in support of an affirmative answer to this question. Radio-activity has supplied a method of analysis—radio-active analysis—surpassing in delicacy any of the previously known methods for the examination of material substance; the application of these methods has not only added to the list of elements but also new classes of elements. First, elements indistinguishable and inseparable by chemical means, yet differing slightly but definitely in their atomic weights. The existence of these "isotopes," as Soddy styles them (a name giving prominence to the fact that such element

occupy the same place in the table of the elements), demonstrates that absolute uniformity in the mass of every ultimate atom of the same chemical element is not an essential, but that "our atomic weights merely represent a mean value around which the actual atomic weights of the atoms vary within certain narrow limits" (Crookes, Address to Section B, 1886).

Whether the possibility of separating isotopes, recently suggested by Dr. Lindemann and Dr. Chapman, will be found capable of experimental realisation, must be left to the future to decide; in fact, in this matter we must adopt the attitude, prevalent in other than scientific circles, of "wait and see."

The investigations in the field of radio-activity have further brought to light that identity in atomic weight may be associated with difference in chemical properties, revealing the existence of a further class of elements for which Dr. Stewart suggests the name "isobares." Further, Dr. Stewart considers that isobaric elements are to be found not alone amongst the radio-active, but some of the normal elements exhibit properties which may be explained on the assumption that they are isobarics. Thus the compounds formed from iron are regarded as indicating the existence of three irons, all having the same atomic weight. One of these, termed ferricum, is tervalent; one, ferrosum, is divalent; whilst the third, ferron, is inert and takes no part in chemical changes. The three are under certain conditions mutually interconvertible. This last condition does not apply in the case of the radio-active isobares.

The elements are to be regarded as divisible into three classes:—(1) Isotopic elements, each set of which have different atomic weights but identical chemical properties; (2) isobaric elements which have identical atomic weights but different chemical properties; (3) normal elements which differ from each other both in atomic weights and chemical properties.

The discovery of X-rays may be acclaimed as having added a new sense to aid us in our investigation of material objects, and to their innumerable services may be reckoned the results which have followed from the investigations of the X-ray spectra of the elements by the late Lieut. Moseley, whose death in Gallipoli in 1915 is one of the many tragedies of the war specially deplored in the scientific world. From the analysis of the X-ray spectra, Moseley has shown that for each element a value can be deduced, which is styled the atomic number and which represents the space in the atomic table the element should occupy. The researches of Rutherford and Andrade on Lead and Radium B have proved that "isotopes" have the same atomic number. Whatever may be the ultimate explanation of the meaning of the atomic numbers, their experimental determination has already proved valuable in the solution of some of the anomalies in the Periodic Table. In addition to the case of isotopes, just referred to, the number of elements between hydrogen and uranium is fixed by finding 92 as the atomic number for uranium, and, further, Moseley's work has revealed that the atomic numbers are in agreement with the order of the chemical sequence, rather than the order of the atomic weights, which is of special interest and value in the cases of tellurium and iodine, and of potassium and argon, the decision in each case proving a welcome support to the position in the table assigned to these elements on chemical considerations.

Again, Moseley's atomic numbers remind us of the arrangement of the elements adopted by Newlands in his communication to the Chemical Society of 1866, in which he set forth the "Law of Octaves," the precursor of the Periodic Law.

In concluding this brief sketch, cognisance should be taken of the speculations of physicists as to the structure of the atom. Already several models of the atom are in the field which leave the uncuttable Daltonian atom far out of view, still in a measure they help to an understanding of some of those regularities exhibited by the elements, and set forth in the natural system. Valency and its vagaries, which we are accustomed to describe by phrases, such as "variable valency," "selective valency," and the like, still call for a full explanation.

I purpose now to direct attention to matters of another nature, which appear to me of interest to chemists, and to that extent have a bearing on the welfare of chemistry in this country.

Among the numerous revelations and surprises of the past five years has been the realisation on the part of the public and the Government of the importance of the chemical industries to the national well-being. The apathy and indifference of pre-war times were replaced by an apparently lively interest in things chemical, and there was what in the religious world would be styled a revival.

Politicians, the Press in all its varied forms, daily, weekly, monthly, and quarterly, took up the subject of our industrial insufficiencies, and emphasised in various ways the importance of research in connection with our industries. Again, the coal-tar colour industry furnished, as it had done again and again, some thirty to forty years ago, the text from which research and its importance was preached. This time the reiteration had the effect that the "aniline phantasm," as I have seen it described, was recognised as a "key industry," important to the vitality of the manufacture of textiles; with the result that the Government, discarding its fiscal policy, was induced to subsidise the enterprise for the manufacture of dyes and other coal-tar products. The negotiations preceding the formation of the "British Dyes Co., Ltd.," have been remarkable as revealing that in the eyes of some, at any rate, special knowledge is a "dangerous thing," and, in fact, was deemed sufficient to exclude its possessors from a seat on the directorate. This is all the more remarkable as the history of similar enterprises in Germany shows the *personnel* of the directorates to be made up of university-trained men, and, in not a few instances, of professors. So that in Germany academic distinction and theoretic learning are not considered as excluding the possession of commercial acumen and those other qualities needed in a successful man of business.

In the early stages of the war the demand for explosives was met by the expansion of already existing factories, the increase in staff of which called for many additional men with chemical training, a call which became unprecedented and insistent when the national factories were founded, so that men and women with a chemical training found an opportunity of putting their knowledge at the service of their country. And in not a few instances those who, for financial reasons, had at the close of their college career taken up a less congenial employment were able to return to the practice of chemistry, for which in their student days they had specially fitted themselves.

In the foreword of the publication "Reports on Costs and Efficiencies for H.M. Factories," issued by the Ministry of Munitions, we are told "when it was decided to commence the erection of new and national factories, and an attempt was made to collect from existing factories the necessary technical data and assistance, did it become evident that, due to the extraordinary demands of the war, there was—practically throughout the entire country—a regrettable lack of available accurate technical data, and an even greater lack of trained technical men—more particularly chemical engineers."

To anyone acquainted with the conditions existing in this country in pre-war days, the lack of "trained technical men" is no matter of surprise. In fact, one cannot fail to be astonished at the phenomenal development of chemical manufacture which has taken place under the directing influence of Lord Moulton, in response to the call from Army to Navy. That men were found capable of taking a part in these varied undertakings cannot, at any rate, be credited to the encouragement which the teaching of chemistry or the students of the science had received from those directing industries, which employ or

should employ the services of chemists. It is no uncommon experience to find the chemist employed simply in the analytical testing of raw materials and manufactured products, and even in the working of processes under their control the potentiality of the chemist is not utilised to the full, as is evident from the following, which is a quotation from the Preface to the brochure, issued by the Ministry of Munitions, to which I have already referred :—

"Since the beginning the policy of the Department with regard to our national factories has been to aim at maximum efficiency in respect of cost and usage of materials.

"For this purpose the greatest efforts have been made to place before all those who are in any way responsible for control full details concerning the working and costs of the factories. This was rather an innovation in the field of chemical manufacture, as until comparatively recently, either intentionally or through negligence, it was customary at many chemical plants to keep the chemists in complete ignorance not only of the cost at their plants but also even of the efficiencies.

"It is amazing that manufacturers can expect improvements in chemical processes when their chemists are kept in ignorance of such vital facts.

"It has happened very often that as soon as detailed figures were seen by chemists at a plant, important alterations and improvements have at once been suggested, the need for which would otherwise never have been noticed."

The condition of service indicated in the passage quoted, together with the low scale of remuneration which obtained hitherto in chemical industries, help to explain the scarcity of the kind of scientific labour referred to in the quotation I have made from the "Foreword."

But are we not told and invited to believe that all this changed, that the records of the magnificent achievements of British chemists in the war have so educated the people and, may we say, the Government also, that the practitioners in chemistry will no longer find it essential that in describing their vocation they should be required to add, unless for special reasons, such prefixes as "analytical," "research," "scientific," or "engineering" to the word chemist, secure in the feeling that by describing themselves as "chemists" their standing, training, and profession will be correctly understood.

Such a feeling akin to despondency, if nothing worse, is pardonable, when realising the fundamental importance of chemistry to our industries, and the thousand and one ways chemical research has ministered to the amenities of our every-day life, there should exist not alone in the mind of the general public, but of the educated also, such a lack of information as has been revealed during the past few years. To wit, the myth woven into the history of the production of glycerin, the confusion in the minds of legislators between phosphates and phosgene. More serious, however, is the fact that the method of investigation employed by the chemist is so little appreciated or understood as to lead one to *imagine* that the *discoveries* and achievements are the results of a species of legerdemain. The production of new colours, a succession of happy thoughts, and that "by an accident the secret of synthetic indigo was unlocked." This last is a quotation from a review entitled "The Value of Scientific Research," published some three ago, and is typical of much that passes muster in appraising the value of chemical research. That the unravelling of the constitution of indigo which occupied Baeyer and his pupils some thirteen years, the account of these investigations covers some 180 pages of Baeyer's collected works, should be summarised in this way appeared to me to call for a protest. My protest was made and I attempted to put the matter in the correct light, showing the synthesis of indigo to be, indeed, a brilliant example of the value of theory and of a practical illustration of the importance of the chemist's conception of the Architecture of Molecules, as exemplified by Kekulé's theory of the constitution of benzene. The protestation evoked a reply from a correspondent, signing himself D.Sc., Ph.D., who sought to justify the description of the revelation of the secret of synthetic indigo by reference to an accident which occurred in the investigation of the processes for the manufacture of phthalic acid, and which certainly greatly facilitated the production of this substance, an intermediate in the manufacture of artificial indigo. So, if the initiated emphasise the unessential, why should we blame the layman and be surprised that well-ordered and planned design should appear to be but the workings of chance, for every such achievement is a witness to the conquest of well-founded theoretical speculation.

But I do not wish to conclude on a despondent note, nor is it right that I should do so, in view of the many activities operating for the promotion of scientific research, and of such evidence as that supplied by the magnificent endowment of the Chemical Department of the University of Cambridge, all of which are evidences of what we may reasonably hope to be a happy augury for the future of chemistry and chemists in this country.

ADDRESS TO THE MATHEMATICAL AND PHYSICAL SCIENCE SECTION OF THE BRITISH ASSOCIATION.

BOURNEMOUTH, 1919.

By Prof. A. GRAY, M.A., LL.D., F.R.S.,
President of the Section.

I HAVE devoted some little time to the perusal of the Addresses of my predecessors in this chair. These have a wide range. They include valuable philosophical discussions of the nature of scientific knowledge and expositions of scientific methods, as well as highly instructive *résumés* and appreciations of the progress of mathematics and physics. But as this is the first meeting of the British Association since the conclusion of peace I have decided to disregard in the main these precedents, and to endeavour to point out, in the first place, some of the lessons which the war has, or ought to have, taught our country and those who direct its policy, and in particular ourselves, whose vocation it is to cultivate and to teach mathematical and physical science.

Before proceeding with this task I must refer to the loss which physical science and the British Association have suffered this year through the deaths of Prof. Carey Foster and Lord Rayleigh. Both of these great physicists were regular in attendance at the meetings of the Association, and they will be greatly missed.

What Carey Foster was as a man of science, as a teacher, and as a friend of all students of physics, has been worthily set forth in the columns of *Nature*, with all the knowledge and affectionate reverence of one who was at once his pupil and his fellow-worker at University College. To that eloquent tribute I will not, though I knew Carey Foster well, venture to add a word.

It is not for me to appraise the work of Lord Rayleigh. But I may say that for something like half a century his name has stood not only for things that are great in physical discovery, but for sanity of judgment, and clarity, elegance, and soundness of treatment of outstanding and difficult problems of mathematical physics. His researches, too, in experimental science have been fruitful in results of the utmost importance in chemistry as well as in physics. With him there was no shirking of the toil of monotonous and systematic observation from day to day in the pursuit of the greatest attainable accuracy—take, for example, his work on electrical units. But his influence on applied mathematics has also been enormous, and places him for all time in the foremost rank of the great physical mathematicians, at the head of which stands Isaac Newton. One has only to read his Treatise on the Theory of Sound,

and his papers on Optics and Wave Theory, to find some of the most striking examples in all scientific literature of the working of a mind not only of the first order of originality, but imbued with a feeling for symmetry of form and clearness of exposition.

Lord Rayleigh's genius was, it seems to me, essentially intuitive and practical. Though he was not given to any striving after the utmost rigidity of formal proof, which, as he himself remarked, might not be more but less demonstrative to the physicist than physical reasons, no man made fewer mistakes. He is gone, but he has left an inspiring example to his order and to his countrymen of a long life consecrated to the object for which the Royal Society, of which he has been the honoured President, was founded, the furtherance of Natural Knowledge.

The part which physical science has played in the conduct of the war on our side has been an important one, but it has by no means been so decisive as it might and ought to have been. And here lies the lessons which I think we can draw from the terrible events which have taken place. Some few people, mostly hostile to or jealous of science, whose vision of facts and tendencies seem to me to be hopelessly obscured by prejudice, would try to impose on the advance of natural knowledge and the supposed increased influence of scientific ideas on the minds of men, or, perhaps more precisely, on the diminution of the study of the so-called humanities, the sole or the main responsibility for the outbreak of war. It seems to me that a good many people allow themselves to be misled by a name. The name *Humanity* is given in the Scottish Universities to the department of the Latin language and literature, and in a wider usage the study of Latin and Greek is referred to as that of *Litteræ Humaniores*. But I am not aware that there is any more humanity, in the common acceptation of the term, about these studies than there is in many others. And experience has shown that the assertion that these studies have a special refining influence, while the pursuit of science has a brutalising tendency, is based on ignorance and partiality. The truth is that the man who knows nothing of science, and he who has neglected the study of letters, are both imperfectly educated.

Well, the accusation I refer to may be dismissed without argument. This is certainly not the time nor the place for a discussion of the causes of the war, or of the ethics of the extraordinary methods introduced into warfare by our enemies. But one thing I will say in this connection. Even poison gas is innocent in itself, and it occurs as a product in perfectly indispensable and eminently useful chemical processes. The extraordinary potency of scientific knowledge for the good of civilised mankind is frequently conjoined with a potency for evil; but the responsibility for an inhuman use of it does not lie with the scientific investigator. The guilt lies at the door of the High Commando, of the high and mighty persons, themselves in feeling and temper utterly unscientific, who approved and directed the employment of methods of attack which destroyed the wounded and helpless, and wrecked for ever the health of many of those who emerged alive from the inferno.

As regards the help which British science was able to render in the defence against the German attack and the operations which followed when the fortune of war changed so dramatically, and the enemy was driven back towards the chain of fastnesses from behind which he originally emerged, one or two obvious reflections must have occurred to everyone. In one form or another these have been referred to by various writers, but I may recall one or two of them, for as a people we are incorrigibly forgetful and appear to be almost incapable of profiting from experience, which, according to the Latin proverb, teaches even fools.

Nearly twenty years ago the urgent necessity for the reorganisation of our military machinery had been, in the view of civilians at least, who had to bear the cost of the war in South Africa, demonstrated *ad nauseam*, but nothing of real importance in the way of reforming the War Office seems to have been done. The shocks we had received were forgotten, and soon the nation returned to its insular complacency, the old party cries resounded in the market-place, the hacks of party politics again resumed their occupation of camouflage and hoodwinking, and the country drifted on towards its fate.

All this time an enormously powerful war machine was being built up on the Continent, and its different parts tested so far as that could be done without actual warfare. The real objects of these preparations was carefully veiled by an appearance of frankness and professions of goodwill, thought it was revealed every now and then by the indiscretions of the German military caste. To these indications and to others the country, ostrich-like, covered its eyes.

Now it is often alleged that men engrossed in the pursuit of science are unbusinesslike, but I think that, if there had been any truly scientific element in the *personnel* of the Government (there never is by any chance), attention would have been directed at a much earlier period to our hopeless state of unpreparedness for the storm which was gradually gathering up against us on the other side of the German Ocean. In discussions of our unpreparedness the emphasis has been placed on our lack of arms and munitions. But important as these are, the entire absence of a scientific organisation to guide us in the exigencies of a defensive war with the most scientific and most military nation of Europe was even more serious.

It is this deficiency in our organisation, a deficiency the avoidance of which would have had no provocative effect whatever, which concerns us here very specially. It is, moreover, a deficiency which, in spite of the lessons they have received, has, I fear, not yet been brought home to our military chiefs. When war broke out nothing had been done to ensure the utilisation for special service in the multitude of scientific operations, which war as carried on by the German armies involved, of the great number of well-trained young scientific men available in the country. The one single idea of our mobilisers was to send men to the trenches to kill Germans, and for this simple duty all except certain munition workers and men in the public service were summoned to the Army. Some modifications were made afterwards, but I am speaking of the failure of prevision at the outset. The need of men for special service, the inevitable expansion of the Navy for patrol and other purposes and the like, were, if they were thought of at all, put aside, without regard to the difficulties which would inevitably arise if these matters were delayed. Even how the new soldiers were to be trained, almost without rifles or machine guns, to meet the Germans in the field nobody knew. And I for one believe that but for the vigour and energy of Lord Kitchener, and the almost too late expression of conviction of our danger, and consequent action, by one outstanding politician, all would have been lost. We worried through, but at a loss of life and treasure from which it will take us long to recover, and which I could wish seemed to weigh more heavily on the minds and consciences of politicians.

The Germans, I believe, had a complete record not only of all their men fitted only for the rank and file, but also of all who had been trained to observe and measure. For the use of even the very simplest apparatus of observation a certain expertness in reading graduated scales, and generally a certain amount of trained intelligence is required. For this the laboratories of Germany amply provided, and the provision had its place in the enemy's mobilisation. Our people apparently did not even know that such a need existed or might arise.

In a letter which I sent to the Council of the Royal Society at the end of 1915 I ventured to propose that the Royal Society might set on foot an organisation of some such character as the following:—First, a Central Committee should be established, in some degree representative of the different centres of scientific teaching and work in pure and applied science. Then this Committee

should nominate representatives at each centre, at least one at each University or College, and one at the headquarters of each local society, such, for example, as the Institution of Engineers and Shipbuilders of Scotland and the similar Society which represents the North-East of England, and has its offices at Newcastle-on-Tyne. This arrangement, it was hoped, would enable the Central Committee to obtain readily information as to what men were available, and would therefore do something to bring the schools of science, and all the great workshops and laboratories of applied science, into co-operation. Thus could be formed at once a list of men available for particular posts, for the task of solving the problems that were certain to arise from day to day, and for the special corps which it was soon, if dimly, perceived were a necessity. Some such linking up of London with the provinces is really indispensable. The districts of, for example, the Tyne and the Clyde are too much ignored in almost all Government action of a general kind.

My letter was printed and sent out to some prominent men by whom its proposals were highly approved. A Conference on its subject was held in London, and two special Committees were appointed. I was a member of one of these, the principal duty of which was to provide scientific men for special service. It included representatives of the various great departments actively engaged in the conduct of the war. For some reason or other, which I never learned, the Committee after a week or two ceased to be called, and, I believe, that little was done in comparison with what might have been accomplished. It was certainly not because such a committee would not work. Everybody was most willing, with proper notice, to attend such meetings as were involved, and to take any amount of personal trouble; moreover, the scheme was such as to provide that there should always be a nucleus of members in London to consult and act in any emergency.

I may briefly refer to one or two examples of the chaos which prevailed and the attempts that were made to cope with it. Very soon after the formation of the first Kitchener Army the organisation of the different corps apparently became a source of anxiety to the War Office. It began to be seen that officers in sufficient numbers could not possibly be obtained by the usual channels, so the expedient (a poor one by itself) was hit upon of placing the nominations to commissions in one at least of the two great scientific corps of the Army—the Royal Engineers—in the hands of the presidents of certain technical Institutions which have their headquarters in London. These gentlemen, with the help of the official secretaries, no doubt did the best they could, but a very regrettable, though perfectly natural, amount of strong feeling was evoked among the young scientifically educated men in the provinces, who were keenly anxious to join this corps. The Engineers, I may hardly say, is no refuge for men who are in the least concerned about their personal safety, for the percentage of casualties among Engineers on active service was notably higher than in the regiments of the line. Over and over again young engineers came to me, and complained that under the arrangements made they had no chance of obtaining commissions, or of qualifying as cadets, and begged me to write to the authorities. Of course, young graduate engineers do not as a rule join Societies such as the Institutions of Civil, Mechanical, or Electrical Engineers, until they have made their way to some little extent, and begun to earn a little money.

The procedure I have indicated had in time to be relaxed, but such a Central Committee as I suggested, with antennæ stretching out to the educational and technical centres of the country, would, I am sure, have recruited the Engineers quickly with the best possible material for officers to be found in the country, to the satisfaction of all concerned. It may be said that full information regarding every man in the country was in the hands of the authorities. In a sense this was true; the information existed in millions of returns, and thousands of pigeonholes, but no attempt was made, or could be made, by office staffs in London, enormous as these quickly became, to digest and utilise it.

A large number of engineers and physicists and many others of mechanical skill and aptitudes found congenial occupation in the Royal Naval Air Service and the Royal Flying Corps; but even there, where things could be better done, since a new force had to be brought into existence, arrangements were to a considerable extent haphazard and ill through out. Excellent self-sacrificing service was rendered by many, who risked and gave their lives, and of what was done we may well be proud. But from a scientific point of view there is room for great improvement. The, as I think, hasty and ill-considered amalgamation of these two branches of the Air Service, in which naval traditions were sacrificed to those of the War Office, which deserved no such deference, will certainly have to be undone in the near future, or very greatly transformed. To anyone who considers the possibilities and probabilities of warfare in the future it appears clear that this country will have to depend more and more upon its Navy, and that an Air Service Corps will be the companion of every division of our Fleet, with landings on the warships. Thus a new and highly scientific service, which will have to be to a great extent naval, will be brought into existence.

Well, then, to return for a moment to my proposal to the Royal Society, why should the organisation which I suggested in 1915 not be established now? I wish all success to the League of Nations, but we shall prove ourselves even greater fools than we have been in the past if we do not use all possible means to prepare ourselves against eventualities. One attempt by our enemies outside our own borders to hold us to ransom has failed. Can we be so sure that no other attempt will ever be made, or that no *casus belli* between ourselves and another great nation will ever arise? This, I notice, is beginning to be assumed even in the midst of the welter of confusion and unrest that exists, and, among others, by just the very people who used to teach that the possibility of war was a great illusion.

The formation of a record of scientific graduates for special service ought not to be difficult. The material already in great measure exists. Each University and College has its roll of graduates or diploma holders, and with slightly more detailed entries these rolls would give the record. Each graduate of a University is kept track of through the necessity for keeping the electoral roll up to date, and it ought to be possible to devise a means of maintaining touch with the diploma holder. If each University or College were a local centre of the Central Committee, the making of the roll of graduates would be achieved at the different local headquarters, and would be a valuable supplement to the O.T.C. work now undertaken so willingly and done so well. The Government machinery which manages the O.T.C. movement might control the keeping of the register which I have suggested.

I turn now to another side of scientific work during the war. It was my lot to serve for nearly three years on the Inventions Panel of the Ministry of Munitions, and as the result of that experience I venture to make some observations on the utilisation of scientific knowledge and genius in the production of inventions useful for the public service. We had an enormous multitude of inventions to consider, and the Panel was divided into Committees for this purpose. For each invention or proposal a file or dossier was prepared and most carefully kept. There were also present at the meetings of the Panel very efficient officers representing different branches of the service. Everything received careful attention, and for the ability and fairness with which the initial examination was made by the corps of examiners, and the *précis* of the invention presented, I have great admiration. Much has been said about the inefficiency and the mistakes of various Government Departments during the war. The Ministry of Munitions Inventions Department was, so far as I could see, eminently well managed.

Many of the so-called inventions were not inventions at all. Some were not at all new; in other cases an idea only was mooted. Could so-and-so not be done? and so on, and the Department was supposed to be grateful for the idea, and to do the rest, besides rewarding the proposer. A favourite notion, which illustrates the diffusion of scientific knowledge among different classes of people, was that of taking a magnet—any magnet—up on an aeroplane, and using it to attract Zeppelins and other aircraft. Others suggested electro-magnets fed by machines which would have involved carrying into the air on an aeroplane a fully equipped power-house! Another favourite notion, inspired, no doubt, by a certain sensational type of article in the fiction magazines, was that of rays charged in some way with electricity, or some other mysterious agency, and therefore intensely destructive.

But there was a residuum of valuable inventions, which fully justified the existence of the Department. These were recommended for further consideration by the various departments of the services, or by General Headquarters. It by no means followed that all that came to this stage received careful further consideration. Everybody was very hard worked, and many were overdriven. And it was by no means certain that when important approved appliances were sent to G.H.Q. a thoroughly well-informed and capable officer would in all cases have the duty of explaining and showing their action. The absence of such an officer, I am sure, often resulted in delay and serious error, and, I fear, also in the rejection of what was in itself exceedingly good, but was not understood. People who knew nothing about the matter took charge, and ordered things to de done which brought disaster to the apparatus. I know of one very important machine which was ruined, with much resulting delay. A Brigadier or Major-General with a confidence born of blank ignorance ordered a motor generator to be put on town electric mains, and of course burnt it out.

Then, again, we were told that G.H.Q. did not want this or that, and here, as in all human affairs, mental inertia certainly played a considerable part. The willingness, however, of some departments to adopt at once a device captured from the enemy was pathetic. Often quite clumsy and relatively inferior contrivances were adopted in the midst of hesitation about our own. Anything German of this sort some people assumed must be good—a foolish idea, the result of want of confidence, often well founded I am afraid, in their own judgment. It is legitimate to copy from the enemy, and in several important things we have not been slow to do so.

The delays that occurred were to some of us at home, who were anxiously dealing with all kinds of contrivances, exceeding exasperating. Some were undoubtedly unavoidable, but others were, as I have indicated, far otherwise. Deficiency in scientific education was the cause. It is to enforce the need for such education that I refer to such matters at all. The "playing fields of Eton" are all very well. I for one do not scoff at what the old saying stands for, but scientific laboratories and good intelligent work in them are indispensable. A man who directs in whole or in part a great machine must know something of its structure and capabilities.

I feel bound to allude to another aspect of the inventions business which to my mind was very serious. In doing so, however, I wish it to be clearly understood that I am criticising a system and in no way here referring to particular individuals concerned in its administration. Various inventions which had passed satisfactorily the first examinations by responsible judges were submitted to technical departments at home to be subjected to practical tests. These inventions were frequently solutions proposed of problems on which technical officers, of the departments required to conduct the tests, had long been engaged. It was natural, indeed inevitable, that some of these officers should have come to regard the solving of these problems as their own special job, and so did not much welcome the coming of the outside inventor. Then, no doubt, they often felt that they were just on the point of arriving at a solution—a feeling that certainly could not facilitate the avoidance of delay. It was manifestly most unfair to ask them to judge the work of the outside inventor, or to place in their hands details of his proposals, for exactly the same reason which in civil life restrains a man from acting as a conjuror in a case in which he is personally interested. Nobody of good sense feels offended when attention is called to such a rule in practice.

Thus I have no hesitation in expressing the opinion that a testing board of practical, well-qualified physicists and other experts, with a properly qualified staff, should be formed for the purpose of carrying out all tests of inventions. No insuperable difficulty would, I believe, be experienced in forming such a board. It should be formed carefully, not by more or less casual nomination of one another by a few persons. Expert knowledge of a subject should be a necessary qualification; the so-called "open mind" of the much-lauded but untrained practical man is not worth having. But on that board neither inside nor outside inventors of the same kind of appliances should have any place, though of course consultation with the author of an invention under test would be absolutely necessary. Also those actually carrying out the tests and those collating the results should not be men in any way in the employment of or under the supervision of inventors, whether "outside" or "inside." It is imperative in the interests of the country that delay in such matters should be avoided, and that all such work should be done without fear or favour.

The value of University and College men trained in science has been thoroughly proved in the Artillery, the Engineers, and in their offshoots, the Special Sound Ranging and Survey Corps, though its recognition by the authorities of Whitehall has been scanty and grudging. Some of the old-fashioned generals and staff officers could not be got to see the use of men who had not been trained to field exercises by a long course of drill. What is the good of officers, they said, who are not skilled leaders of men? This is the old crude idea again of destroying Germans with rifles, bayonets, and hand grenades. The falsity of these antiquated notions has now, I believe, been amply demonstrated.

The objection to these men, however, lies a good deal deeper. Even those scientifically educated officers who came into the new armies when they were formed, and were trained by the service of years of warfare superadded to the initial course of drill, have been demobilised in a nearly wholesale manner, without the least regard to even very exceptional qualifications. Many of these were, it seems to me, the very men who ought, above all, to have been retained in the service. Now (though, as I write, improved regulations are being issued) they are to a great extent to be replaced by the Public School cum Sandhurst young gentlemen, who, it appears, are the "pucca" officers *par excellence*.

The old system of the rule of politician chiefs whose only or main function is to sign the edicts of heads of departments seems to have returned in full force, and the coming of the cleansing Hercules that many people desire for the War Office does not seem to be within the bounds of possibility.

The real cause of the prevailing neglect of science, with all its pernicious results, is that almost all our political leaders have received the most favoured and fashionable form of public school education, and are without any scientific education. An education in classics and dialectics, the education of a lawyer, may be a good thing—for lawyers; though even that is doubtful. For the training of men who are to govern a State whose very existence depends on applications of science, and on the proper utilisation of available stores of energy, it is ludicrously unsuitable. We hear of the judicial frame of mind which lawyers bring to the discussion of matters of high policy, but in the majority of scientific cases it is the open mind

of crass ignorance. The result is lamentable; I myself heard a very eminent counsel declare in a case of some importance, involving practical applications of science, that one of Newton's laws of motion was that "friction is the cause of oscillations!" And the helplessness of some eminent counsel and judges in patent cases is a byword.

As things are, eminence in science is no qualification, it would even seem to be a positive disqualification, for any share in the conduct of the affairs of this great industrial country. The scientific sides of public questions are ignored, nay, in many cases our rulers are unconscious of their existence. Recently in a discussion on the Forestry Bill in the House of Lords a member of that illustrious body made the foolish assertion that forestry had nothing to do with science; all that was needed was to dig holes and stick young trees into them. Could fatuity go further? This hereditary legislator who, as things are, has it in his power to manage, or mismanage, the conversion into available energy of the radiation beneficently showered on a certain area (his area) of this country of ours does not seem to be aware that the growing of trees is a highly scientific industry, that there are habits and diseases of trees which have been profoundly studied; that, in short, the whole subject of silviculture bristles with scientific problems, the solutions of which have by patient labour been to a considerable extent obtained.

Take also the case of the Dyes Industries. The publicists and the good business men—the supermen of the present age—who wish to control and foster an industry which owes its very existence to an English chemist, refuse to have on the Committee which is to manage this important affair any man of scientific eminence, and no remonstrance has any effect. These great business men are, as a rule, not scientific at all. They are all very well for finance, in other respects their businesses are run by their works-managers, and, in general, they are not remarkable for paying handsomely their scientific assistants.

I myself once heard it suggested by an eminent statesman that an electrical efficiency of 98 per cent might by the progress of electrical science be increased fourfold! This, I am afraid, is more or less typical of the highly educated classical man's appreciation of the law of conservation of energy, and he is, save the mark, to be our minister or proconsul, and the conservator of our national resources. It is not surprising, therefore, that in connection with a subject which for several weeks occupied a great space in the newspapers, and is now agitating a large section of the community, the nationalisation of our coal mines, there was not a single word, except perhaps a casual vague reference in the Report of the Chairman, to the question, which is intimately bound up with any solution of the problem which statesmen may adopt, I mean the question of the economic utilisation, in the interests of the country at large, of this great inheritance which Nature has bestowed upon us. In short, are Tom, Dick, and Harry, if we may so refer to noble and other coalowners, and to our masters the miners, to remain free to waste or to conserve at their own sweet will, or to exploit as they please, this necessity of the country's existence?

The fact is that until scientific education has gone forward far beyond the point it has yet reached, until it has become a living force in the world of politics and statesmanship, we shall hardly escape the ruin of our country. The business men will not save us; as has been said with much truth, the products of modern business methods are to a great extent slums and millionaires. It lies to a great extent with scientific men themselves to see that reform is forthcoming, and more power to the Guild of Science and to any other agency which can help to bring about this much-needed result.

While scientifically educated men, whether doing special work or acting as officers, have been held of far slighter account in the services than they ought to have been, for physicists as such there has been little or no recognition, except, I believe, when they happened to be ranked as research chemists! How did this happen? Why, the various trades asserted themselves, and the result was a sufficiently long list of "reserved occupations," a list remarkable both for its inclusions and for its exclusions. There was, for example, a class of "opticians," many of whom have no knowledge of optics worth mentioning. They are merely traders. One of these, for example, the proprietor of a business, made a plaintive appeal to myself as to how he could determine the magnifying powers of certain field-glasses which he wished the Ministry of Munitions to purchase. But for a young scientific man, even if he were an eminent authority on theoretical and practical optics, but who was not in the trade, there was no place.

Research chemists received their recognition in consequence of the existence of the Institute of Chemistry. I am extremely glad to find that something is now being done to found an Institute of Physics. I hope this movement will be successful, and that it will be thoroughly practical and efficient. I hope its President and Council, its Members and Associates, will be jealous for science, and especially for physics. It ought to be a thoroughly hard-working body, without any frills, destitute of work value. They have an example in the General Medical Council, which has so effectively cared for the interests of the medical profession.

I am glad that something is being done at last for the organisation of scientific research. This movement has started well in several, if not in all, respects, and I wish it all success. There are, however, one or two dangers to be avoided, and I am not sure—I may be much too timid and suspicious—that they are fully recognised, and that the result will not be too much of a bureaucracy. Somehow or other I am reminded by the papers I have seen of the remark of a poor man who, asking charity of someone in Glasgow, was referred to the Charity Organisation Society of that city. "No thank you," he said; "there is a good deal more organisation than charity about that institution." So I hope that in the movement on foot the organisation will not be more prominent than the science, and the organisers than the scientific workers.

There is to my mind too much centralisation aimed at. Everything is to be done from London; a body sitting there is to decide the subjects of research and to allocate the grants. There may be a good deal to be said for that in the case of funds obtained in London. But apparently already existing local incentives to research work are to be transferred to London. The Carnegie Trust for the Universities of Scotland, soon after its work began, inaugurated a scheme for research work in connection with these Universities. The beneficiaries of the Trust, it is well known, must be students of Scottish nationality. The action of the Trust has been most excellent, and much good work has been done. Now, so far as chemistry and physics are concerned, it has been proposed, if not decided, to hand over to the organisation in London the making of the awards, a process of centralisation that will probably not end with these subjects. I venture to protest against any such proceeding. The more incentives and endowments of research that exist and are administered in the provinces the better. Moreover, this is a benefaction to Scottish students which ought not to be withdrawn and merged in any provision made for the whole country, and administered in London by a bureau which may know little of the Scottish Universities or of Scottish students. The bureau might, with equal justice or injustice, be given command of the special-research scholarships of all the Universities both in England and Scotland, and administer them in the name of the fetish of unification of effort. I do not know, but can imagine, what Oxford and Cambridge and Manchester and Liverpool would say to that. But even Scotland, where of course we know little or nothing about education of any kind, may also have something to

say before this ultra-centralisation becomes an accomplished fact.

There is, it seems to me, another danger to be avoided besides that of undue centralisation in London. In most of the statements I have seen regarding the promotion of research work the emphasis seems to be on industrial research, that is in applied science. This kind of research includes the investigation of physical and chemical products of various kinds which may be used in arts and manufactures, and its deliberate organised promotion ought to be a commercial affair. I observed, by the way, with some amusement, that according to the proposals of one Committee for Appliad Science, which is prepared to give grants and premiums for researches and results, the Professor or Head of a Department, from whom will generally come what are most important, the ideas, is to have no payment. He is supposed to be so well paid by the institution he belongs to as to require no remuneration for his supervision of the Committee's researches. And the results are to be the sole property of the Committee !

(To be continued).

HOW THE NITROGEN PROBLEM HAS BEEN SOLVED.*

By HENRY JERMAIN MAUDE CREIGHTON, Department of Chemistry, Swarthmore College, Member of the Institute.

(Concluded from p. 148.)

VII. Comparative Data.

It may be of interest to compare the relative efficiencies of the arc process, the cyanamide process, and the direct synthesis of ammonia, as these represent the three most important methods for the fixation of atmospheric nitrogen. By expressing coke, coal, and other fuel in units of electrical energy, the quantity of nitrogen that may be fixed for a given energy consumption may be obtained. Thus, with one kilowatt year there can be fixed by the direct synthesis of ammonia about 830 kilogrms. of nitrogen ; by the cyanamide process, about 380 kilogrms. of nitrogen ; and by the arc process, about 130 kilogrms. of nitrogen. The low energy consumption in the direct synthesis of ammonia is offset to some extent by the difficulties involved in operation and the heavy dead charges ; that in the cyanamide process by the large labour requirements and the number of operations involved. On the other hand, while the energy requirements of the arc process are high, it must be remembered that the labour involved is small, that its operation is extremely simple, and that the raw materials are free.

In Table XII. are given data relating to investment and operation costs, per ton of fixed nitrogen, for the arc. cyanamide, and direct synthesis of ammonia processes, (Nitrate Supply Committee Recommendations, *Journ. Ind. Eng. Chem.*, 1917, ix., 841).

Table XII.

	Arc process.	Cyanamide process.	Direct synthesis of ammonia by The Haber process.	Direct synthesis of ammonia by The General Chemical Co. (De Jahn) process (*a*)
Product	35 p.c. HNO_3	NH_3	NH_3	NH_3
Investment (dols.)	1410 (*b*)	440 (*b*)	540	300
Operating costs (dols.) (*c*) ..	170	150 (*d*)	119	97
Product	96 p.c. HNO_3	96 p.c. HNO_3	96 p.c. HNO_3	96 p.c. HNO_3
Investment (dols) (*e*) ..	1550	670	570	530
Operating costs (dols.) (*f*) ..	220	270	239	217

* From the *Journal of the Franklin Institute*, April, May, and June, 1919

(*a*) Estimates on the General Chemical Co. process are based on war time construction costs. All others on normal prices.
(*b*) Power plant investment reckoned at 100 dols. per horse power.
(*c*) Amortisation for cyanamide as charged by operating companies. Amortisation for Haber 20 per cent of plant cost for repairs, interest, and depreciation. Amortisation for Arc and Modified Haber 12·5 per cent for interest and depreciation. 5.00 dols. per ton of product for repairs.
(*d*) Cyanamide production 122 dols., ammonia from cyanamide 28 dols., total 150 dols.
(*e*) Except for Arc process, includes ammonia plant as given ; powder additional, 10 dols. ; oxidation and absorption, 140 dols. ; concentration, 40 dols. ; steam plant, 40 dols.
(*f*) Except for Arc process, includes ammonia costs as given ; oxidation, 50 dols. ; concentration, 70 dols. No allowance made for unoxidised ammonia.

During the past five years rapid progress has been made in the fixation of atmospheric nitrogen, especially by the cyanamide process and by the direct synthesis of ammonia. As a result of this advance, greatly stimulated by the war nearly one-third of the nitrogen used by the Allies fo' military explosives in the autumn of 1918 was obtained from the atmosphere. That the nitrogen problem has been solved is attested by the following data showing the progress of the nitrogen industry :—

Annual Producing Capacity in Tons of Nitrogen.

	1914.	1918. Autumn.	1919. Spring estimate).
United States.			
Cyanamide	0	46,000	91,000
Synthetic ammonia	0	9,000	9,000
Total atmospheric nitrogen	0	55,000	100,000
By-product ammonia	38,000	90,000	100,000
Grand total	38,000	145,000	200,000
The World.			
Cyanamide	53,000	265,000	343,000
Synthetic ammonia	12,000	109,000	109,000
Arc process nitrogen	10,000	15,000	15,000
Total atmospheric nitrogen	75,000	389,000	467,000
By-product ammonia	300,000	350,000	360,000
Sodium nitrate	430,000	500,000	520,000
Grand total	805,000	1,239,000	1,347,000

In the original communication (*Journal of the Franklin Institute*, April—June, 1918) the author appends a copious Bibliography of the Literature on and relating to Nitrogen Fixation and the Oxidation of Ammonia.

NOTES ON A FORM OF ANTI SUCK-BACK DEVICE APPLICABLE TO EVOLUTION METHODS OF ANALYSIS.

By P. L. ROBINSON, M.Sc. (Dun.), A.I.C.

Chemists engaged in the volumetric determination of sulphur in steel are familiar with the inconvenience resulting from the sucking back of the absorbing fluid towards the end of the reaction. This may be caused by a draught blowing away the heating flame, or, alternatively, where it is the practice to boil the contents of the flask, the steam may be condensed at a greater rate than it is produced.

With this difficulty in view, the apparatus to be described was devised. It has since been successfully applied to a volumetric arsenic (in metals) apparatus, and may be of use in other methods.

I. *Anti Suck-back Head.*

The underlying idea is that of a liquid trap joint which which may be made very successfully with a piece of 1 inch diameter glass tubing and two rubber bungs. a 1 inch bung. This tube is closed at the top except for two apertures—one of which is the delivery tube, C, and the other the stem of a small headed thistle funnel, A. This stem reaches to within ¾ inch of the bottom of the wide tube, B. Through the bung, G, closing the lower end of the wide tube, B, passes the delivery tube, D, from the flask. The end of this tube D is raised 1 inch above the lower end of the funnel stem A, which height determines the volume of liquid in the trap.

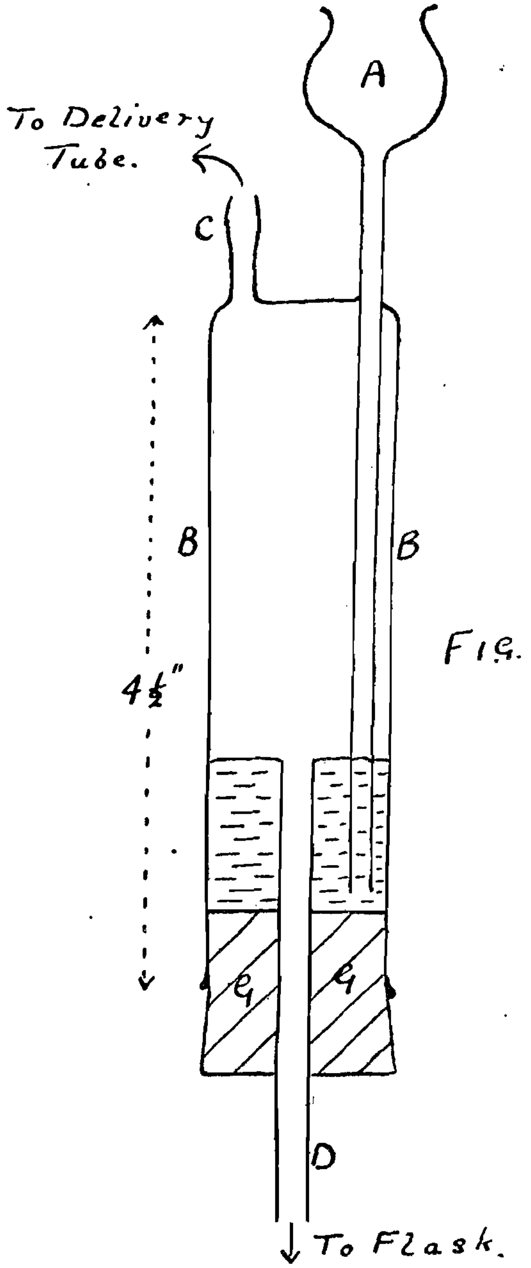

Fig. 1.

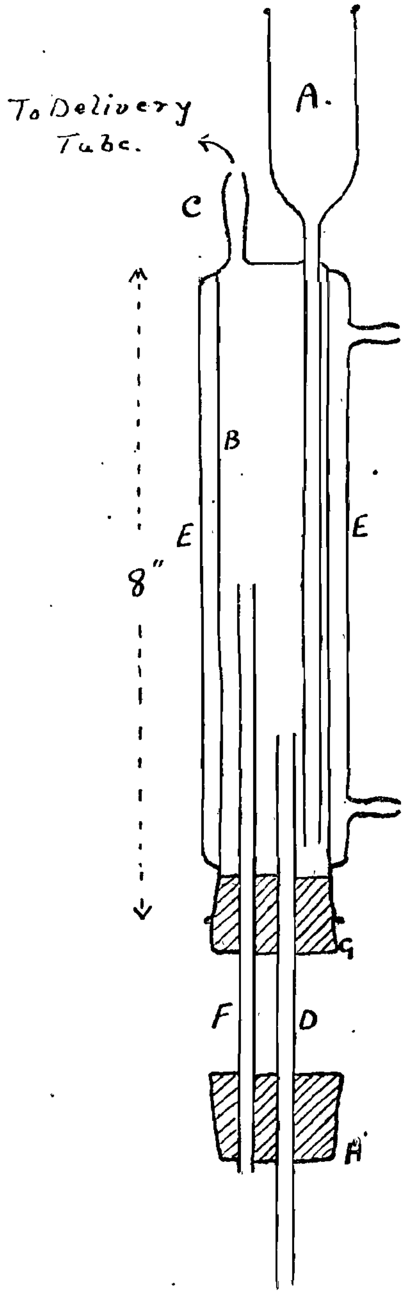

Fig. 2.

However, the form shown in the diagram (Fig. 1) is much neater. It was made by Messrs. J. Preston, Sheffield, at a cost of 18 shillings per dozen. It consists of a piece of glass tubing about 4½ inches long and wide enough to take

In working, when the pressure of the enclosed gas is above atmospheric, liquid is forced up the funnel stem, and, conversely, when the pressure is reduced by more than 1 inch of water below atmospheric, air is drawn into the

apparatus. The length of the funnel stem determines the upper limit of pressure possible; in practice the writer found 5 inches to be ample.

It will be noted that the device also acts as a trap for splashes.

II. *Anti Suck-back Condenser Head for Evolution Sulphur in Steel.*

This piece of apparatus was designed to meet the case of steel which, either by its nature or the size of the drillings, dissolves very slowly. For this purpose a condenser, an anti suck-back head, and an acid delivery funnel were incorporated into one piece of glass work (Fig. 2). It was made by Messrs. Orme and Co., Manchester, at a cost of 10s. 6d.

The funnel, A, is in this case much larger, as it is used to deliver the acid direct on to the steel. The wide tube, B, is about 8 inches long, and is completely jacketed by a wider tube, E, thus forming a condenser. Through the bung, G, closing the lower end of the wide tube, pass two tubes; one, D, having its upper end 1 inch above the end of the funnel stem and passing 3 inches below the flask bung H, the other having its upper end 3 inches above the end of the funnel stem and passing just through the flask bung.

This condenser head is fixed in a special stand, which allows of it being raised to attach and remove the flask.

In working, the flask containing the steel is first attached. The acid mixture is poured into the funnel and passes down the tube D into the flask, while the air and the immediate products of the reaction escape therefrom by the second tube, F. Immediately afterwards a few cc. of water are run down the funnel to wash the last of the acid into the flask. By this means the action of acid on the rubber bung is prevented.

It has been found when using this condenser head that no hydrochloric acid distils or splashes over into the absorption vessel, and that once the determination is started no attention is required.

ADDITION COMPOUNDS OF AROMATIC AMINES AND THEIR NITRO-DERIVATIVES WITH METALLIC SALTS.*

By JOSEPH REILLY, M.A., D.Sc., F.R.C.Sc.I.

CERTAIN *p*-nitroso-derivatives obtained during a study of the butylarylamines were characterised by the formation of addition products with various metallic salts (Reilly and Hickinbottom, *Trans. Chem. Soc.*, 1918, cxiii., 105, 928). *p*-Nitrosodibutylaniline yielded double salts with the chlorides of zinc, cadmium, copper (cupric), mercury (mercuric), iron (ferric), manganese (ous), tin (stannic), and with the nitrates of nickel, cobalt, and copper. 5-Nitroso-*n*-butyl-*o*-toluidine also gave a double salt with cupric chloride.

It has been observed that secondary and tertiary amines, such as mono- and di-butylanilines, are able to combine with metallic salts.

Derivatives of methylaniline and butylaniline with cobaltous chloride, zinc chloride, and cadmium chloride were prepared and compared.

Although the derivatives of the alkylanilines with metallic salts must be considered as formed by the calling into play of the residual valency of the nitrogen, the double salts with *p*-nitrosoalkylanilines may either be considered as nitrogen or as oxygen addition substances. Pickard and Kenyon (*Trans. Chem. Soc.*, 1907, xci., 896) showed that nitrosobenzene also combined additively with metallic salts. The colour of the *p*-nitrosodimethylaniline zinci-chloride differed also from that of salts which are considered to be true nitrogen addition compounds. They suggested that these compounds of *p*-nitroso-alkylanilines were due to the residual valency of the oxygen atom.

The comparative ease with which the different mono-substituted anilines yield addition compounds has been studied. It is found that aminophenols form a double complex more readily than nitroanilines. Also the stability of the addition compounds of the alkylarylamines is less than that of the corresponding metallic salt derivatives of the primary arylamines. In general, by altering the basicity of the amino group, or by causing an alteration in the disposal of the valencies of the nitrogen atom, the power to yield additive products is altered.

Taking into consideration the behaviour of nitroso-hydroxy compounds, and the ability of nitrosobenzene to yield addition compounds, it is possible in *p*-nitroso-alkylarylamines that not only the amino group, but also the nitroso group may have an influence on the formation of a complex with a metallic salt.

* Read before the British Association (Section B), Bournemouth Meeting, 1919.

INTRAMOLECULAR REARRANGEMENT OF THE ALKYLARYLAMINES.*

By JOSEPH REILLY, M.A., D Sc.,
and
WILFRED J. HICKINBOTTOM.

THE intramolecular change brought about by heating the hydrochlorides of the alkylanilines under pressure is well known (Hofmann, *Ber.*, 1872, v., 720). It is now shown that not only the hydrochloride, but also certain addition compounds of the secondary and tertiary amines with metallic salts are capable of undergoing this change on heating. Compounds of the type $B.RCl_2$ (where B represents one molecule of a monovalent base, and R one atom of a divalent metal), produced by the addition of chlorides of zinc, cobalt, and cadmium, to the secondary amines, readily yield alkyl nuclear substituted amines, on heating under pressure. Unless the assumption is made that these double compounds readily split off hydrogen chloride, it is difficult to reconcile these facts with the view that methyl chloride is an intermediate product in the formation of *p*-toluidine from methylaniline double salts.

In the alkylarylamines each group occupies a definite space and has a *certain* definite vibration path. If a change of conditions occurs each group will tend to occupy a position in which the vibration is least restricted. This may occur simply on heating, or by combination or reaction with another compound. In the case of heating alone only a slight effect is apparent, but in presence of a substance which can cause an alteration in the arrangement of the molecule some profound change occurs. The extent of the rearrangement and consequently the ease with which the change occurs, will depend on several factors, among which the steric effect of constituent groups and the free valency have an important influence.

It might be expected that, in the series of alkylanilines, the larger groups would show a tendency to be removed before the smaller ones. Comparative experiments with monoalkylanilines indicate that the total amount of change including intramolecular rearrangement, brought about on heating in sealed tubes, does not differ greatly whether the alkyl group is butyl or methyl. It is suggested that the other influences, such as the increasing steric hindrance imposed by the larger alkyl groups, may modify the reaction.

* Read before the British Association (Section B), Bournemouth Meeting, 1919.

NOTES.

THE Manchester Literary and Philosophical Society resumes its activities on October 7 under the presidency of G. Elliott Smith, M.A., M.D., F.R.S. The meetings are held bi-monthly in the afternoon and evening alternatively.

FARADAY SOCIETY.—The offices of the Society have been removed to 10, Essex Street, Strand, W.C. Secretary, Mr. F. S. Spiers.

THE Birmingham Metallurgical Society commences the new session in October. The Presidential address will be given by F. C. A. H. Lantsberry, M.Sc., F.I.C., at the Birmingham Chamber of Commerce on October 2, at 7 p.m.

NATIONAL PHYSICAL LABORATORY.—The Lord President of the Council has appointed Prof. Joseph Ernest Petavel, D.Sc., F.R.S., M.I.Mech.E., &c., to be Director of the National Physical Laboratory in succession to Sir Richard Glazebrook, C.B., F.R.S., who retires on reaching the age limit on September 18. Prof. Petavel is Professor of Engineering and Director of the Whitworth Laboratory in the University of Manchester. He is a member of the Advisory Committee for Aeronautics of the Air Ministry. He was educated at University College, London, and undertook scientific research at the Royal Institution and at the Davy Faraday Laboratory until 1898. He was elected John Harling Fellow of the Owens College, Manchester, in 1900, and was Scientific Manager of the Low Temperature Exhibit of the British Royal Commission for the St. Louis Exhibition, 1904.

THE Glass Research Association, established in accordance with the Government's scheme for encouraging industrial research, has been licensed by the Board of Trade as a company not trading for profit. The secretary is Mr. E. Meigh, 7, Seamore Place, W. 1.

THE Department of Scientific and Industrial Research have approved the Memorandum and Articles of the British Refractories Research Association, which are now under consideration by the Board of Trade. Mr. A. C. Rann, 14, Great George Street, Westminster, S.W. 1, will act as secretary of the Association.

A. AND F. DENNY have reprinted, by permission of the Organising Committee of the British Scientific Products Exhibition, the lists of books compiled and issued by them in the catalogue of the Exhibition lately held in Central Hall, Westminster. The books have been carefully selected, and in their particular subjects are the best obtainable, and include quite a number of American publications. The list, however, does not cover the whole of their extensive stock.

CATALOGUES FOR BELGIUM.—H.M. Vice-Consul at Charleroi states that he has received various complaints from important Belgium firms to the effect that almost all the business correspondence they receive from the United Kingdom is insufficiently stamped. This applies also to catalogues, &c., one firm stating that they have had to pay surtax amounting to as much as three francs on a single parcel of printed matter. In order to avoid creating, however unintentionally, a bad impression among Belgian traders, it is important that United Kingdom manufacturers and merchants should make their business correspondence and literature compare well with that of trade rivals from other countries.

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REVIEW OF INORGANIC CHEMISTRY.*

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Researches in inorganic chemistry have not been very numerous during the last few years, and relatively few articles on the subject have appeared. The chemical industries of the war have absorbed the time of all who have been endeavouring to assist in the task of national defence, and energy has been chiefly expended in perfecting improvements to ensure a better yield of products of all kinds the consumption of which has been enormously increasing.

The great chemical factories of all countries have been multiplied, and many industries have been established which did not exist before the war.

The great need for sulphuric and nitric acids has led to the growth of enormous factories in which the quantities required for explosives have been prepared. In most countries, and particularly in France, sulphuric acid was made before the war by the old lead chamber process, and there was no need to concentrate it for most industries in which it was used. Except in exceptional cases, acid of strength 50—52° B., just as it came from the lead chambers, was sufficient for all industrial purposes. But the need for acid of strength 66° B. for the manufacture of different explosives has made it necessary to concentrate the chamber acid, and the production of concentrated acid has enormously increased. It is difficult to foresee what will become of the huge plants which have been installed at great expense; the manufacture of ammonium sulphate and superphosphates will not consume more than one-tenth of the quantity made during the war.

Nitric acid, since the beginning of the war, has been made by the classical Valentiner process, and all needs have been met by the many factories built. One difficulty has been the enormous quantity of sodium bisulphate obtained as a by-product in the process. Many attempts have been made to utilise it, but very few of them have been adopted in practice.

When the price of sodium nitrate increased, and also to augment the production of nitric acid, branches of the Norwegian Company were formed, and using natural water-power nitric acid was made from the air by the well known method of Birkeland and Eyde. The oxidation of ammonia and its transformation into nitric acid has also been undertaken, and the establishment of cyanamide factories to produce ammonia. The investigation of methods of preparing synthetic ammonia has not been generally followed by commercial applications, while, on the contrary, in Germany extraordinary developments have come about.

To synthesise ammonia from its elements very high temperatures must be employed, which, however, may be lowered by the use of a catalyst, although even then the gases must be exposed to very high pressures. According to Haber and Le Rossignol a temperature of 550° C. and a pressure of 180 atmospheres will give a yield of 10—12 per cent of ammonia, in presence of catalysts such as osmium, uranium, or iron. Zenghelis has tried to bring about the combination at the ordinary or a slightly higher temperature, by employing nitrogen and hydrogen in the atomic state, either nascent or occluded in metals. When these gases are passed over very finely divided platinum or palladium, even at a red heat no trace of ammonia is formed. If a mixture of 3 volumes of hydrogen and 1 of nitrogen is passed through a tube containing 10 cc. of water heated to 100°, containing a finely-divided metal as catalyst, positive results were obtained, ammonia being formed in appreciable quantities. Still better results were obtained when water acidified with sulphuric acid was used. Spongy platinum, palladium, or platinum black gave only small quantities of ammonia, while Paal and Amberger's colloidal palladium or Carey Lea's colloidal silver gave good yields. Colloidal copper, mercury, and silver also led to the formation of the compound.

By preparing hydrogen in the atomic state by dissolving a metal in an acid, or by electrolysis, Zenghelis has succeeded in bringing about its union with nitrogen. For example, with a current of nitrogen passing through a tube containing 10 cc. of 2/N sulphuric acid, and 3 grms. of powdered zinc, heated to 90°, ammonia is formed. These experiments clearly show the activity of nascent or occluded hydrogen, for at a low temperature and ordinary pressures in presence of traces of catalysts it leads to the synthesis of ammonia with molecular nitrogen. But if both the gases are in the atomic state remarkable results are obtained. When a current of hydrogen is passed through a solution containing 1·32 grm. of ammonium chloride and 1·72 grm. of sodium nitrite in presence of a catalyst, the nitrogen evolved according to the reaction $NaNO_2+NH_4Cl=NaCl+2H_2O+2N$ should produce 5 litres of a centinormal solution of ammonia. At 70—90° 0·5 grm. of colloidal platinum gave a yield of 1756 cc., and 0·5 grm. of colloidal palladium gave 2060 cc. The volume of hydrogen passing into the solution was 5 litres per hour. In the case in which only the hydrogen was atomic, the greater quantity of ammonia formed did not produce more than 32 cc. of a centinormal solution; with both gases in the atomic state sixty times as much was formed.

Hempel and Steinau have also described a method of manufacturing ammonia, not requiring high temperatures or pressures and employing both gases in the atomic state. The principle of the reaction is based upon the decomposition of ammonium chloride by iron. When this salt is heated in presence of iron ammonia and hydrogen are formed, $2NH_4Cl+Fe=FeCl_2+2NH_3+H_2$. If the reaction is carried out in presence of nitrogen this gas unites with the nascent hydrogen to give two molecules of ammonia, so that the final reaction which occurs at 300° and 50 atmospheres, $3Fe+6NH_4Cl+N_2=3FeCl_2+8NH_3$, shows that two molecules of ammonia are formed over and above those arising from the decomposition of the ammonium chloride. The eight molecules of ammonia precipitate iron hydrate in the solution of ferrous chloride, and the hydrate is then reduced to iron, the ammonium chloride being regenerated. The ammonium chloride vapour produced in this reaction is corrosive and has to be carefully handled. To do away with it the authors have tried to bring about the formation of ammonia by the use of solutions. The results should lead to the formation of 94—99 per cent of ammonia.

It is already known that the direct synthesis of ammonia can be effected by bringing the elements together under a high pressure at a temperature above 400° in presence of certain catalysts, such as the nitride or carbide of cerium, uranium, tungsten, molybdenum, iron, lithium, or other metals. The yields are always small, 10 to 15 per cent at the most. According to a process patented by Cederberg and Backstrom, a yield of 40 to 50 per cent can be obtained at a temperature much below 400° if the catalyst employed is a nitride which is unstable at a relatively low temperature. The use of such a temperature enables the reaction to be carried out under a higher pressure, without any fear of action on the apparatus employed. Copper asbestos, zinc powder, copper hydride or ferrocyanide, mercury bromide or nitride are the best catalysts. The reactions are (M representing the metal):—

* Slightly abridged from *Revue Générale des Sciences*, xxx., No. 14, July, 1919.

$$\begin{cases} M+N = MN, \\ MN+3H = M+NH_3. \end{cases}$$

$$\begin{cases} M+H = MH, \\ 3MH+N = 3M+NH_3. \end{cases}$$

For instance, if nitrogen at 10 to 15 atmospheres is passed over a *mixture of mercury and mercurous chloride* heated to 300—350°, the chloronitride, $2HgCl_2.Hg_3N_2$, is formed, and is afterwards reduced by the hydrogen. The ammonia obtained is liquefied by carbonic acetone snow

Many patents relating to this synthesis of ammonia have been taken out; some suggest the use of different catalysts, others variations in the temperature and pressure. In the American patent of Bosch and Mittasch hydrogen and nitrogen, freed from all traces of moisture, are passed at 600° over a catalyst made of iron, cobalt, nickel, and molybdenum. The yield is greater the drier the reacting gases are. The use of high pressure is not indicated. Vogt passes the mixture of hydrogen and nitrogen over a heated anhydrous metallic chloride. Ammonium chloride is thus formed and sublimes at a higher temperature. Ellis brings about the combination in presence of cerium obtained by the reduction of the purified oxide. The presence of rare earths, such as La, Di Yt, makes combination take place more easily. These metals are mixed with wood charcoal, and the reaction is carried out at 370—450° under a pressure of 60 to 80 atmospheres. Another method is to pass H and N alternately over a layer of carbides of cobalt, iron, titanium, magnesium, barium, or a mixture of these carbides. They are heated electrically in a suitable furnace. With the carbides of calcium and iron the reactions are—

$$2CaC_2+FeC_2+6N = Ca_2F(CN)_6,$$
$$Ca_2Fe(CN)_6+18H = Ca_2FeC_6+6NH_3.$$

None of these reactions have been applied commercially. The Haber and Le Rossignol process alone, the property of the Société Badoise d'Aniline, has been very extensively employed during the war, for it was already worked out in 1914.

Some patents dealing with cyanamide have also been taken out. They are not of such great interest, because this industry was well known and thoroughly established in various countries. Attempts have been made to increase the amount of nitrogen fixed by carbides by the addition of certain catalysts or indifferent substances, the nature of them having been kept secret. The cyanamide obtained would be more porous and easier to grind (Carlson).

Polzenius employs sodium or potassium sulphide. The effect is such that when they are mixed with calcium carbide nitrogen begins to be absorbed at 750°. Moreover, the transformation of the carbide is complete, and a product can be obtained containing more than 20 per cent of nitrogen. It is known that in modern commercial processes, in order to augment the absorption of nitrogen by calcium carbide, calcium chloride or fluoride are usually employed. But the former gives a hygroscopic product which absorbs water and loses a certain amount of ammoniacal nitrogen, and if the fluoride is employed the temperature of fixation cannot be lowered below 900°. Both these disadvantages are obviated by the use of sulphides, and moreover a cyanamide is obtained which has a higher percentage of nitrogen. Cyanamide is an excellent nitrogenous fertiliser, but it has the great drawback of being very pulverulent, which causes accidents due to its causticity and losses when it is spread. Attempts have been made to make the powder granular, and Roussel has recommended a very convenient process which consists in mixing it with 5 per cent of aluminous earth, such as clay, kaolin, marl, &c., and 0·35 per cent of casein, in order to increase the agglutinating power; water made alkaline is added, and the whole is stirred. The paste thus obtained easily granulates.

Finally, the oxidation of ammonia, obtained by synthesis or from cyanamide or nitrides, has also been the subject of many patents. Bosch and Mittasch use for this oxidation a catalyst formed of Bi_2O_3 mixed with an oxide of iron, manganese, copper, cobalt, nickel, chromium, uranium, cerium, yttrium, zinc, thorium, or a metal of the platinum group, or a derivative of silicon or titanium, either spread on refractory bricks or not. Ellis employs a compound of silver and an oxygen acid of another metal, and he gives as an example silver molybdate. Ammonia and air also yield oxides of nitrogen. Copper vanadate has also been used as catalyst. These processes have, however, not been applied industrially. The oxidation of ammonia by air in presence of platinum gives good results. The production of nitric acid and products leading to ammonia has been very actively pushed in different countries. There need be no fear of seeing the production diminished, seeing that the soil is the natural outlet for these compounds, either in the form of ammonium nitrate or sulphate, or of cyanamide. Other inorganic industries besides the manufacture of nitric and sulphuric acids have increased their output during the war. The chlorine industry in particular has been enormously extended, and the manufacture of phosgene gas, $COCl_2$, depends upon this industry. Besides the classical method of preparing this gas Whitehouse's process must be mentioned; it consists in bubbling carbon monoxide through a layer of liquid chlorine at a temperature below 34°, until the gas is no longer absorbed. Chlorine may also be used for making chloride of sulphur, employed in the vulcanisation of rubber.

In the manufacture of hydrogen according to the Badische Company, in the reaction of water vapour on carbon monoxide or gases containing it in presence of nickel as catalyst, metals such as iron can also be used, or its oxides with the addition of nickel. The latter has considerable activity, and there is no need to fear the formation of methane.

According to Buchanan a maximum yield of hydrogen is obtained when carbon monoxide and water vapour are passed over a catalyst formed of metallic couples, such as the iron-copper couple obtained by heating iron oxide with sodium carbonate. The product is washed with water to remove the alkali, and after being dried it is reduced with hydrogen. When the metal is cooled it is moistened with a solution of copper nitrate, and the product is heated in a current of hydrogen. At 500° this complex completely decomposes the gaseous mixture, $CO+H_2O=CO_2+H_2$. A silver-iron couple is also very active.

In the process of the Chemische-Elektron hydrogen is produced by the action of charcoal, or gas containing CO and water-vapour on alkaline or alkaline earth oxides or their hydrates. The charcoal employed is very porous; *e.g.*, lignite or wood charcoal. The gas and water-vapour when passed over a mixture of lime and charcoal at a pressure of 10 atmospheres gives practically pure hydrogen. This reaction has been studied by Léo Vignon, and the results show that a gas very rich in hydrogen can be obtained thus. At a temperature of 600—800°, if the mixture of lime and charcoal is homogeneous and intimate, the following reactions may occur:—

$$C+CaO+2H_2O = CaCO_3+2H_2.$$
$$2C+CaO+2H_2O = CaCO_3+CH_4.$$
$$3C+CaO+2H_2O = CaCO_3+C_2H_4.$$

These three reactions are exothermic and liberate respectively 25, 47, and 17 calories. Ten grms. of gas-coke mixed with 35 grms. of quicklime gave a gas consisting of 65 per cent of hydrogen and 25 per cent of methane. Only 58·7 per cent of hydrogen was obtained when the coke was replaced by lamp-black. The amount of water-vapour is important, for it reacts with the methane according to the equation $CH_4+H_2O=CO+3H_2$. Hence with excess of water-vapour a higher percentage of hydrogen can be obtained. With the same lime and charcoal mixture and excess of water-vapour only 8 per

cent of methane remains, and 85—87 per cent of hydrogen is formed. When water-vapour is not present in excess a mixture of methane and hydrogen is obtained similar to that existing in coal-gas. Vignon obtained a product of the following composition:—H, 69·3 per cent; CH_4, 20·46 per cent; CO, 5·28 per cent; O, 0·6 per cent; N, 3·96 per cent; CO_2, 0·4 per cent.

As the calcium carbonate formed in this reaction can be decomposed again, lime may be regarded as being the catalyst, and it is believed that this reaction has been tested on a commercial scale. Vignon has also studied the decomposition of carbon monoxide by water-vapour. In presence of lime it is transformed above 400° into a mixture of methane and hydrogen,—

$$CO + Ca(OH)_2 = CaCO_3 + H_2.4CO + 2Ca(OH) = \\ = 2CaO + 3CO_2 + CH_4.$$

When the total formation of CO into H and CH_4 was attempted by repeatedly passing CO over hydrated lime he obtained with a gas containing 98·5 per cent of CO:—

After the first passage, 88·5 per cent of hydrogen and hydrocarbons.

After the second passage, 94·5 per cent of hydrogen and hydrocarbons.

After the third passage, 99·5 per cent of hydrogen and hydrocarbons.

Thus the transformation was practically total. The use of other catalysts, such as iron, nickel, copper, silica, alumina, &c., also enables large quantities of CH_4 and H to be obtained from CO. This would lead to a better method of utilising carbon, for it is thus possible to gasify the coke obtained from coal. The transformation of tar into gas would not be practicable, as it would involve the loss of a very important substance from a commercial point of view. The study of the origin of tar has taken a new aspect owing to the work of Pictet and his pupils (*Revue Génerale des Sciences*, xx., 579). Little is known about the chemical composition of coal, but according to the hypothesis first suggested by Berthelot it is thought that in it there exists an immediate principle, the pyrogenation of which yields tar. Berthelot did not lay stress upon this point, but worked out the theory of its formation from acetylene. Many authors have described attempts to remove well defined products from coal by means of neutral, alkaline, or acid solvents. Benzene, pyridine, quinoleine, aniline, phenol, &c., remove a certain amount of soluble matter, and in the case of quinoleine the proportion may reach 47·3 per cent. Pictet, by exhausting 5½ tons of Sarre coal with benzene, isolated for the first time hydroaromatic compounds and olefines, analogous to those found in certain petrols.

More recently F. Fischer and Glund, by treating certain coals with benzine in a special vessel the temperature of which was gradually raised to 235° and under a pressure of 40 to 50 atmospheres, extracted 6·6 per cent of soluble products, while Pictet only obtained 0·25 per cent of extract. These products form a slightly fluid mass with a strong odour of petrol. But the authors could not get any definite compound from them, so that the credit for the study of the extraction of coal rests with Pictet and his pupils. The same authors subjected charcoal, powdered and suspended in water, to the action of a current of ozone. They found that the substance gradually disappeared, leaving a brown solution of a substance like caramel and having a strongly acid reaction. This reaction suggests the formation of ozonides, and hence the presence in coal of compounds of ethylenic structure. It was evidently substances of this nature which Fischer isolated for the first time from coal.

Haworth and Irvine have described a method of preparing hypochlorous acid, which consists in passing chlorine through a series of flasks containing water and a catalyst, which is preferably copper oxide or one of its salts, a salt of nickel or of cobalt. On shaking continuously a liquid containing 2 per cent of free hypochlorous acid is finally obtained, and the acid can be separated by distillation. A fairly large amount of the catalyst is required. For two litres of water it is necessary to use 80 to 100 grms. of copper salt. Perchloric acid can be prepared by the electrolysis of a normal solution of hydrochloric acid, using a current of 0·5 ampères per square cm. of electrode.

Divers and Ogawa have shown that the reaction between sulphur dioxide and ammonia does not lead to the formation of the compound, $(SO_2)_5(NH_3)_4$. According to the latter author two well defined products are formed. One is amido-sulphurous acid NH_2SO_2H, pale yellow in colour, and the second, which is white, is the ammonium salt of this acid,—

$$NH_3 + SO_2 = SO{<}^{OH}_{NH_2} \quad 2NH_3 + SO_2 = SO{<}^{ONH_4}_{NH_2}.$$

These compounds are somewhat unstable, and soon after they are formed the presence of an orange or reddish coloured substance can be detected, obtained by their decomposition. Even at the temperature of the boiling-point of liquid ammonia the heat produced by the reaction is enough to cause the decomposition, if precautions are not taken to regulate the currents of the reacting gases.

Thionyl and sulphuryl chlorides $SOCl_2$ and SO_2Cl_2 are the most important chlorinating agents, and North and Thomson have used them for transforming sulphur and phosphorus into the corresponding chlorides. By heating sulphur with sulphuryl chloride in a sealed tube sulphur chloride is obtained—$SO_2Cl_2 + 2S = S_2Cl_2 + SO_2$. This reaction begins slowly at 95° and is total after a few hours at 125°. When white or red phosphorus is heated with an excess of SO_2Cl_2 it undergoes chlorination in two stages. The trichloride of phosphorus is first formed, and is then converted into pentachloride — $3SO_2Cl_2 + 2P = 2PCl_3 + 3SO_2PCl_3 + SO_2Cl_2 = PCl_5 + SO_2$. With thionyl chloride sulphur reacts in a sealed tube from 150° according to the equation $2SOCl_2 + 3S = SO_2 + 2S_2Cl_2$, and phosphorus from 125° gives a mixture of phosphorus trichloride, sulphur dioxide, and sulphur trichloride $4SOCl_2 + 2P = 2PCl_3 + 3SO_2 + S_2Cl_2$. If the temperature is raised to 180° the pentachloride is formed in small quantities, at the same time as phosphorus chlorosulphide $PSCl_3$.

A method of preparing pure sulphuric acid, free from arsenic and selenium, consists in making ammonium carbonate act on natural calcium sulphate. On heating the following double decomposition occurs—$SO_4Ca + CO_3(NH_4)_2 = CaCo_3 + SO_4(NH_4)_2$. The ammonium sulphate thus obtained is decomposed by means of phosphoric acid, when sulphuric acid is liberated. The ammonium phosphate is then heated to a high temperature, and is thus decomposed into ammonia and phosphoric acid, which are both used again in the reaction. Carbon dioxide and calcium sulphate are thus the materials necessary for the production of sulphuric acid by this method.

Another reaction which may be applied commercially depends upon the action of sulphuretted hydrogen upon copper sulphate; insoluble copper sulphide and sulphuric acid are thus formed, and the latter goes into solution, from which it can be obtained by evaporation, after separation of the metallic sulphide. The latter when oxidised in rotating drums, heated to 300°, is transformed into copper sulphate, which can be used for the fixation of a fresh quantity of sulphuretted hydrogen. This very simple reaction, however, does not occur completely unless two or three times its weight of copper oxide is added to the sulphide to be oxidised. This process might be immediately applied to the removal of sulphuretted hydrogen from illuminating gas, and the sulphuric acid formed might be used to make ammonium sulphate. A recent method for removing sulphurous compounds from illuminating gas, due to Clowes, consists in passing the gas at 230° over refractory bricks impregnated with reduced nickel. The carbon disulphide and hydrogen are thus converted into carbon and sulphuretted hydrogen. The latter, when passed over iron oxide, is removed, the carbon deposited

on the bricks is oxidised and the surface of the nickel can be used for another purification. By this process the percentage of sulphur can be reduced to ½ grm. per 100 cubic feet of gas.

A very stable and concentrated preparation of hydrogen peroxide can be obtained by the classical method of decomposing barium dioxide by syrupy phosphoric acid. The best results are obtained by mixing 30 litres of acid of density 1·7 with 60 litres of water, adding gradually (and stirring) 75 kgrms. of barium dioxide (87 per cent), and not allowing the temperature to exceed 50–70°. The barium phosphate crystallises out and can be separated by filtration from the hydrogen peroxide solution, which contains 16 per cent of H_2O_2. Sodium dioxide very readily oxidises certain gases, and Zenghelis has shown that their action on Na_2O_2 is generally much more energetic than has been hitherto believed. With carbon monoxide the temperature of the reaction gradually rises and sodium carbonate is formed, $Na_2O_2+CO=Na_2CO_3$. Carbon dioxide reacts very vigorously, the temperature rises considerably and oxygen is evolved, $Na_2O_2+CO_2=Na_2CO_3+O$. The oxygen oxidises substances mixed with the alkaline peroxide such as iron, aluminium, magnesium, or organic substances. If the thermic effect of these two reactions are compared it is seen that it is much greater in the first, when 123,330 calories are evolved, than in the second (55,225) calories). Thus the second reaction should be the less energetic, but actually the opposite is the case. It is probable that the reaction in the second case takes place in two simultaneous phases; first, sodium percarbonate is formed and then decomposes in the second phase—

$$2CO_2+Na_2O_2=C_2O_6Na_2$$
$$C_2O_6Na_2=CO_3Na_2+CO_2+O.$$

The thermic result is the same, but the formation of the endothermic intermediate substance, which decomposes as soon as it is formed, causes a rapid and more energetic reaction. *Hydrogen sulphide also produces a very energetic* reaction in presence of Na_2O_2. The temperature rises and the peroxide becomes incandescent and fuses. In presence of air the H_2S ignites, water is formed and then attacks the peroxide, and the reaction becomes complete. Hofmann has shown that when carbon monoxide reacts with copper oxide in presence of an aqueous solution of alkali it is slowly transformed into CO_2, which is absorbed by the alkali. The addition of traces of metals of the platinum group and specially of iridium to the mixture of copper oxide and alkali greatly increases the velocity of oxidation. It is evident that the carbonyl gradually reduces the copper oxide in this reaction. But if oxidation is effected by the oxygen of the air, in contact with metallic copper mixed with an alkaline solution, the carbon monoxide is oxidised in the cold two or three times as quickly as when it is in contact with copper oxide, the surfaces of contact being equal. It is probable that in this reaction the metal is converted into oxide Cu_2O_3 or CuO_2 which constitutes the actual oxidising agent. The addition of a trace of iridium to the copper does not affect the oxidising power, but increases the capacity of absorption of the surface for CO. A 15 per cent potash solution is employed as alkali.

If the oxidation of CO in an alkaline medium is easily realised in presence of copper, which appears to act as a catalyst, on the contrary the hydrogenation of the gas in contact with nickel is difficult, and does not occur if the nickel is impure. If the reacting gases contain substances which are toxic towards the metal (chlorine, sulphur, phosphorus, &c.) the hydrogenation is stopped. The Badische Company have tried to improve the reaction and retard the poisoning of the nickel by adding to it certain oxides of earthy metals containing the rare earths, or beryllium or magnesium. An intimate mixture of this catalyst with the oxide can be obtained by precipitating simultaneously the hydrates, oxides, or carbonates from a solution of a mixture of salts and then heating the mixture of the precipitates, which is reduced at as low a temperature as possible by pure hydrogen or any other convenient agent. The catalytic activities of nickel, cobalt, and iron are very high. Carbon monoxide is thus easily transformed into methane. According to a second patent difficultly fusible oxides of high melting-point, such as those of titanium, uranium, manganese, vanadium, or tantalum, mixed with the catalysing metal, can also be employed. These mixed catalysts can also be used for the hydrogenation of various organic molecules, and especially for the transformation of oils into solid fatty substances.

It is known that when sulphur vapours in excess are passed, together with carbon monoxide, through a porcelain tube heated to a red heat carbon oxysulphide, COS, is formed in small quantities. Thau obtained it by making potassium sulphocyanate react at 0° with sulphuric acid diluted with its own volume of water. The gas is collected over mercury; it is soluble in its own volume of water, which acquires first a sweet and then a sulphurous taste. Stock and Kuss obtained it by the action of HCl upon ammonium thiocarbonate $CO{<}^{SNH_4}_{NH_2}+2HCl=2NH_4Cl+COS$. In order to purify it, it is passed through a 33 per cent soda solution, to absorb the CO_2 and H_2S which are formed at the same time. After having been dried with calcium chloride and phosphoric anhydride it is condensed by means of liquid-air and finally fractionated. In the pure state it is an odourless gas which does not give a precipitate with baryta or sulphur copper in solution. It is slowly decomposed by water but can be kept permanently in sunlight. It fuses at —138·2° and boils at —50° under 760 mm. One part of water dissolves 0·54 volumes at 20°; *it is more* soluble in alcohol which dissolves 8 volumes, and in toluene which dissolves 15 times its volume. It is slowly and *regularly absorbed* by an 8 per cent soda solution.

The direct bromination of silico-methane SiH_4 has never been effected owing to the violent action of bromine on this hydride. And the intermediate products SiH_3Br and SiH_2Br_2 are not known, as in the case of methane, $SiBr_4$ being always obtained at once. Silicobromoform, $SiHBr_3$, has been prepared by passing HBr vapour over silicon heated to a red heat. However, the complete series of chloro derivatives of silico-methane exists, and besides the tin and tetrachlor derivatives, prepared in the same way as the bromine derivatives (action of chorine and HCl upon silicon), monochlorosilicomethane, SiH_3Cl, and the dichloro compound, SiH_2Cl_2, have been prepared by the action of HCl upon silicon heated to 300—400°. These derivatives show a constant difference in boiling-point.

SiH_3Cl	boils at	−10°
SiH_2Cl_2	„	12°
$SiHCl_3$	„	35°
$SiCl_4$	„	58°

Stock and Somes̈i have now prepared the hitherto unknown mono- and dibromo-silico-methane by making bromine act on an excess of silico-methane at a temperature of −80° to −70°; they can be separated by fractional distillation. The technique of the operation consists in depositing solid bromine on the walls of a large vessel and passing an excess of the gas over it. Monobromsilico-methane SiH_3Br is a colourless gas possessing an acid smell; its density is 1·533, it boils at 1·9°, and melts at −94°. It can be kept over mercury for some time without undergoing decomposition. When exposed to the air it explodes, giving silicic acid and brown silicon. It reacts with cold water according to the equation—$2SiH_3Br+H_2O=2HBr+(SiH_3)_2O$, the latter compound being silico-methyl oxide analogous to methyl oxide $(CH_3)_2O$. In presence of a 30 per cent solution of soda bromosilico-methane decomposes, giving up its hydrogen and yielding sodium silicate—$SiH_3Br+3NaOH=SiO_3Na_2+NaBr+3H_2$. Dibromosilico-methane SiH_2Br_2 is a colourless mobile liquid,

having high refracting powers, of density 2·17, boiling at 66°, and melting at −70°. It can be kept for a long time in a closed vessel, but catches fire in the air. It is very sensitive to the action of moisture, decomposing into HBr and a solid of formula $(SiH_2O)_n$, analogous to $(CH_2O)_3$. In contact with alkalis it decomposes, giving up its hydrogen—

$$SiH_2Br_2+4NaOH = SiO_3Na_2+2NaBr+2H_2+H_2O.$$

As to the oxide of silico-methyl $(SiH_3)_2O$, obtained from the decomposition of bromo-silico-methane by water, it is a colourless gas which does not catch fire spontaneously but burns with a bright flame, depositing silicon. It boils at −15·2° and melts at −144°. Its constants are very close to those of silico-ethane Si_2H_6 (fusion −132·5°, boiling-point −15°). It is not appreciably soluble in water. When mixed with oxygen it explodes or catches fire, giving silica and water—$(SiH_3)_2O+3O_2=2SiO_2+3H_2O$. This oxide is the first example of a compound of this nature in the organic silicon series. Like the oxide of methyl it is easily chlorinated, but all the hydrogen in the molecule is replaced by chlorine, and at −125° only the hexachloro derivative is formed, $(SiCl_3)_2O$. It is a colourless liquid boiling at 137° and solidifying when cooled, giving crystals which melt at −33°. It is rather unstable, decomposing into silica and silicon chloride—$4(SiCl_3)_2O=2SiO_2+6SiCl_4$. It differs essentially in one respect from methyl oxide—the latter is stable in presence of alkalis, while silico-methyl oxide decomposes in contact with 30 per cent soda $(SiH_3)_2O+H_2O+4NaOH=2Na_2SiO_3+6H_2$.

If the boiling points of the four known bromine derivatives are compared it is found that there is no fixed difference as in the case of the chlorine derivatives, at any rate for the first two terms. The boiling-points are—

SiH_3Br	1·9°
SiH_2Br_2	66
$SiHBr_3$	111
$SiBr_4$	147.

A new element, wilsonium, found in monazite sands from the United States, especially from Montana, has been described. Unlike the metals of the rare earths which are trivalent—though sometimes exhibiting lower valencies—it is monovalent. Its atomic mass is 204·6°. It is brownish grey in colour, with a rather dull metallic lustre. Its various salts are white and transparent. It possesses the radio-active properties of uranium and radium though to a much smaller extent, and like them it constantly emits helium even at the ordinary temperature. It affects photographic plates. Like the metals of the rare earths it possesses the property of uniting at a high tempeature with nitrogen, oxygen, and hydrogen, giving the nitride, oxide, and hydride.

To the list of metallic carbonyls already known must be added ruthenium carbonyl, which was obtained in the Mond laboratory by heating very finely powdered ruthenium in an atmosphere of carbon monoxide to a temperature of 300° and under a pressure of 400 atmospheres. It is soluble in alcohol, which enables it to be extracted from the medium in which it has been produced, and especially from unchanged ruthenium. Other metallic carbonyls can very easily be separated by volatilisation, but ruthenium carbonyl is non-volatile. Metallic carbonyls have begun to be applied commercially; in particular the utilisation of nickel carbonyl $Ni(CO)_4$ in the extraction of nickel has enabled the poor nickeliferous minerals of Canada to be treated. Lessing has also suggested employing nickel carbonyl with hydrogen to transform oils into solid fatty substances. By passing a current of the carbonyl through an oil heated to 170° to 180° the carbonyl is decomposed into metallic nickel and CO. The nickel is present in the oil in an extremely fine state of division and the smallness of the particles greatly aids hydrogenation. But it is curious to note that Maxted has shown that the presence in the hydrogen of 6 or 8 per cent of carbon monoxide makes nickel lose the power of hydrogenating organic compounds and specially oils. Lessing thinks that this arrest of hydrogenation is due to the decomposition of the CO in contact with nickel, giving carbon which stops up the pores of the metal. The reaction does not take place when the nickel carbonyl is mixed with hydrogen, and an oil would be solidified even if the percentage of nickel carbonyl corresponded to 50 per cent of carbon monoxide. Many refractory metallic oxides have never been reduced by means of hydrogen. Only alumino-thermic methods or electrical methods have enabled us to get the metals in the pure state or as castings. Newbery and Pring have tried to reduce them by heating in contact with hydrogen to a temperature of about 2000°, and under a pressure of 150 atmospheres, in a special apparatus consisting of a crucible of magnesia heated by a current passing through a tungsten spiral. The water vapour produced in the reaction was absorbed by metallic sodium. In these conditions chromium oxide Cr_2O_3 and manganese dioxide are reduced to the corresponding metals, and the two metals thus obtained are probably purer than when prepared by any known method. Their boiling-point is 1230° for manganese, within 5°, and 1615° for chromium, with a possible error of ± 15°. The other refractory oxides examined have not given the metal, reduction being stopped at a lower oxide. Thus V_2O_5, M_2O_5, and TiO_2 gave VO, MO, and TiO. U_3O_8 gave UO_2, and cerium dioxide gave the sesquioxide. Alumina, magnesia, zirconia, and thoria were not reduced by this method.

As platinum is becoming more and more rare and dear it is worth noticing that it is possible in many cases to replace it by another metal of very high density (16·6) tantalum. This metal, however, is not like platinum unoxidisable at high temperatures, which limits its application; but at temperatures below 200° it is not attacked by oxygen. It only begins to oxidise in air at a dull red heat, then at a higher temperature it burns, giving tantalum oxide. Thus crucibles or capsules of O tantalum could not be made for use at these temperatures, but as it is not attacked by alkalis, nor by acids (except HF), nor even by aqua regia, it may be employed on condition that it is not raised to a red heat. Tantalum electrodes can always be used instead of those made of platinum, if the precaution is taken of covering the anode with a thin electrolytic deposit of platinum.

(To be continued).

The Catalogue and Sample Room at the British Vice-Consulate at Liége having now been open for six months the moment appears opportune to review the work which has been done. The response of British firms for catalogues and samples of small bulk has hardly fulfilled expectations, but it is to be hoped that an important increase in the number received will be assured, as the facilities which this organisation provides for bringing British products to the notice of Belgian buyers are realised. It should hardly be necessary to state that catalogues for Belgium should be in French if possible, with metric measurements, &c. The number of firms who have sent publicity matter up-to-date is slightly in excess of 300. Thanks to the far-seeing and patriotic support of the editors of the leading trade journals, of which no fewer than 25 are furnished gratuitously, the normal equipment of this section is rendered much more important than would otherwise be the case, and the journals are studied by a large number of prospective customers for British goods. The organisation described above being largely in the nature of an experiment, the continuance and development of which must depend upon the results attained, it is urgently requested that all firms who succeed in doing business by means of the publicity offered them should notify the fact to the British Vice-Consul, Liége.

ADDRESS TO THE MATHEMATICAL AND PHYSICAL SCIENCE SECTION OF THE BRITISH ASSOCIATION.

Bournemouth, 1919.

By Prof. A. GRAY, M.A., LL.D., F.R.S, President of the Section.

(Concluded from p. 159.

There is in this delightfully calm proposal at least a suggestion of compulsion and of interference with institutions and their staffs, which ought to be well examined. Also some light is thrown on the ideas of such people as managing directors of limited liability companies, who are members of such a committee, as to what might reasonably be expected of men of high attainments and skill, whose emoluments taken all round are on the whole miserably insufficient.

I think that it is in danger of being forgotten that, after all, pure science is by far the most important thing. Most of the great applications of science have been the products of discoveries which were made without any notion of such an outcome. Witness the tremendous series of results in electricity of which the beginning was Faraday's and Henry's researches on induction of currents, and the conclusion was the work of Hertz on electric waves. From the first came the production and transmission of power by electricity, from the last the world has received the gift of wireless telegraphy. I am not at all sure whether the great men who worked in the sixty or seventy years which I have indicated would have always received grants for proposed researches, which to many of the good business directors and other supermen serving on a great bureau of investigation, had such then existed, would have appeared fantastic and visionary. In research, in pure science at least, control will inevitably defeat itself. The scientific discoverer hardly knows whither he is being led: by a path he knows not he comes to his own. He should be free as the wind. But I must not be misunderstood. Most certainly it is right to encourage research in applied science by all available and legitimate means. But beware of attempting to control or "capture" the laboratories of pure science in the Universities and Colleges of the country. Let there be also ample provision for the pursuit of science for its own sake; the return will in the future as in the past surpass all expectation.

I had intended to say something about scientific education as exemplified by the teaching of physics. I have left myself little time or space for this. I cannot quite pass the matter over, but I shall compress my remarks. In the first place I regard dynamics, especially rotational dynamics, as the foundation of all physics, and it is axiomatic that the foundation of a great structure should be soundly and solidly laid. The implications of dynamics are at present undergoing a very strict and searching examination, and now we may say that a step in advance has been taken from the Newtonian standpoint, and that a new and important development of dynamics has come into being. I refer of course to the new theories of relativity, which are now attracting so much attention. I hope to learn from the discussions, which we may possibly have, something of the latest ideas on this very fundamental subject of research. It is a matter for congratulation that so many excellent accounts of relativity are now available in English. Some earlier discussions are so very general in their mathematical treatment and notation as to be exceedingly difficult to master completely. I have attacked Minkowski's paper more than once, but have felt repelled, not by the difficulties of his analysis, but by that of marshalling and keeping track of all his results. Einstein's papers I have not yet been able to obtain. Hence it is a source of gratification to have Professor Eddington's interesting Report to the Physical Society and the other excellent treatises which we have in English. But continual thought and envisaging of the subject is still required to give anything approaching to instinctive appreciation such as we have in ordinary Newtonian dynamics. I venture to say that the subject is pre-eminently one for physicists and physical mathematicians. In some ways the new ideas bring us back to Newton's standpoint as regards so-called absolute rotation, a subject on which I have never thought that discussions of the foundations of dynamics had said absolutely the last word.

The better the student of physics is grounded in the older dynamics, and especially in the dynamics of rotation, the sooner will he be able to place himself at the new point of view, and the sooner will his way of looking at things begin to become instructive.

With regard to the study of physics in our Universities and Colleges, I had written a good deal. I have put that aside for the present, and will content myself with only a few general observations. First, then, it would, I think, be conducive to progress if it were more generally recognised that dynamics is a physical subject and only secondarily a mathematical one. Its study should be carried on in the departments of physics, not in those of mathematics or in separate departments of applied mathematics. It is, or ought to be, essentially a subject of the physical lecture-room and the physical laboratory. The student should be able to handle rotating bodies, to observe and test the laws of precession and nutation, to work himself, in a word, into an instinctive appreciation of at least the simpler results of rotational theory. He should learn to think in vectors, without necessarily referring either to Hamilton or to Grassmann. Some people appear to censure the use of vector ideas without the introduction at the same time of some form of vector notation. I do not feel drawn to any system of vectors in particular—all have their good points, and in some ways for three dimensional work the quaternion analysis is very attractive—but vector *ideas* are of the very utmost importance.

Hence I deprecate the teaching, however elementary, which as a beginning contents itself with rectilineal motion. The true meaning of rate of change of a directed quantity, even of velocity and acceleration, is missed, and instead of having laid a foundation for further progress the teacher, when he desires to go beyond the mere elements, has practically to relay his foundations, has, in fact, to extract imperfect ideas from his pupils' minds and substitute new ones, with the result that a great deal of avoidable perplexity and vexation is produced. The consideration of the manner of growth of vectors—the resultant vector or it may be component vectors, according to convenience—is the whole affair. As an illustration of what I mean, take this:—A vector quantity has a certain direction, and also a magnitude L. It is turning in a certain plane with angular speed ω. This turning causes a rate of production of the vector quantity about a line in that plane and perpendicular to the former, and towards which the former is turning, of amount $L\omega$. Thus a particle moving in a curve with speed v has momentum mv forwards along the tangent at the position of the particle. The vector is turning towards the principal radius (length R) of curvature at the point at rate v/R. Hence towards the centre of curvature momentum is growing up at the time rate mv^2/R.

Dealt with in this way, with angular momentum instead of simple momentum, the motions of the principal axes of a rigid body give the equations of Euler instantly and intuitively, and all the mind-stupefying notions of centrifugal couples, and the like, are swept away.

With regard to mathematics, the more the physicist knows the better, and he should continually add to his store by making each physical subject he takes up a starting-point for further acquisition. Some very philistine notions as to mathematics prevail, and are very mischievous. For example, I once heard an eminent practical engineer declare that all the calculus an engineering student re-

quires could be learned in an hour or two. This is simply not true, nor is it true, as some exponents of ultra-simplicity seem to suggest, that the professional mathematical teacher wilfully makes his subject difficult in order to preserve its esoteric character. Like the engineer or physicist himself, he is not always so simple as he might be; but the plain truth is that no good progressive mathematical study can be carried out without hard and continued application of the mind of the student to the subject. And why should he depend on the mathematical teacher? Let him be his own teacher! There are plenty of excellent books. If he has a determination to help himself he will, if he makes a practice of reserving difficulties and returning to them, find them vanish from his path.

As I have said, I am specially interested in rotational dynamics. In the course of the war I have been appalled by the want of appreciation of the principles of this subject, which, in spite of considerable acquaintance with the formal theory, seemed to prevail in some quarters. I do not refer to mistakes made by competent people—it is human to err—but to the want of appreciation of the true physical meaning of the results expressed by equations. A gyrostat as ordinarily considered is a closed system, and its dynamical theory is of a certain kind. But do away with the closedness, and the dynamical theory is quite a different affair. Take, as an example, the case of two interlinked systems which are separately unstable. This compound system can be made stable even in the presence of dissipative forces. A certain product of terms must be positive, so that the roots of a certain determinantal equution of the fourth degree may all be positive. The result shows that there must be angular acceleration, not retardation, of the gyrostat frame. This acceleration is a means of supplying energy from without to the system, the energy necessary to preserve in operation the functions of the system.

I have ventured to think this stabilising action by acceleration of the compound motion very important. It is lost sight of by those who consider and criticise gyrostatic appliances from the usual and erroneous point of view. Also I believe that it is by analogy a guide to the explanation of more complicated systems in the presence of energy-dissipating influences, and that the breaking down of stability or *death* of the system is due to the fact that energy can no longer be supplied from without in the manner prescribed for the system by its constitution.

I had just concluded this somewhat fragmentary Address when the number of *Nature* for July 24 came to hand, containing a report of Sir Ernest Rutherford's lecture at Royal Institution on June 6. The general result of Sir Ernest's experiments on the collision of α-particles with atoms of small mass is, it seems to me, a discovery of great importance, whatever may be its final interpretation. The conclusion that "the long-range atoms arising from the collision of α-particles with nitrogen are not nitrogen atoms, but probably charged atoms of hydrogen or atoms of mass 2," is of the utmost possible interest. The α-particle (the helium atom, as Rutherford supposes it to be) is extraordinarily stable in its constitution, and probably consists of three helium nuclei each of mass 4, with two attached nuclei of hydrogen, or one attached nucleus of mass 2. The intensely violent convulsion of the nitrogen atom produced by the collision causes the attached nuclei, or nucleus, to part company with the helium nuclei, and the nitrogen is resolved into helium and hydrogen.

It seems that, in order that atoms may be broken down into some primordial constituents, it is only necessary to strike the more complex atom with the proper kind of hammer. Of course, we are already familiar with the fact that radio-active forces produce changes that are never produced by so-called *chemical* action; but we seem now to be beginning to get a clearer notion of the *rationale* of radio-action. It seems to me that it might be interesting to observe whether any, or what kind of, radiation is produced by the great tribulation of the disturbed atoms and continued during its dying away. If there is such radiation, determinations of wave-lengths would be of much importance in many respects.

I may perhaps mention here that long ago, when the cause of X-rays was a subject of speculation, and the doctrine that mainly found acceptance was that they were not light waves at all, I suggested to the late Professor Viriamu Jones that radiation of extremely small wave-length would be produced if atomic or molecular vibration, as distinguished from what in comparison might be called molar vibration, could be excited. An illustration that suggested itself was this:—Take a vibrator composed of a series of small masses with spring connections. If these masses are of atomic or molecular dimensions any ordinary impulse or impact would leave them unaffected, while vibrations of groups of them, depending on the connections, would result. But the impact on one of the masses of a hammer of sufficiently small dimensions, and mass would give vibrations depending on the structure of the mass struck, and independent of the connections, just as the bars of a xylophone ring, while the suspended series of bars, if it swings at all, does so without emitting any audible sound. This is, I believe, in accordance with the theory now held as to X-rays. We now have some information as to the mode of producing a local excitement so intense as to cause not merely atomic disturbance, but actual disruption of the atomic structure. Further developments of Sir Ernest Rutherford's experiments and of his theory of their explanation will be eagerly awaited.

THE MECHANISM OF THE "*n*-BUTYL ALCOHOL AND ACETONE" FERMENTATION PROCESS.*

By JOSEPH REILLY, M.A., D Sc.,
and
WILFRED J. HICKINBOTTOM.

AMONG the more recent applications of bacteriology to technical processes is the conversion of carbohydrates into a mixture of *n*-butyl alcohol and acetone (A. Fernbach and E. Strange, E. P. 21073, 1913). Certain bacteria are known, as for example, *granulobacter butylicum*, *bacillus amylobacter*, and the butylic bacillus of Fitz, *tyrothrix tenuis*, which, under certain conditions, convert carbohydrates mainly into *n*-butyl alcohol and acetone, producing, in addition, carbon dioxide and hydrogen, together with small quantities of acids and other alcohols (chiefly ethyl). From 100 grms. of maize may be produced 7 grms. of acetone, 16 grms. of *n*-butyl alcohol, 2 grms. of volatile fatty acids, 19 litres of carbon dioxide, and 16 litres of hydrogen at 20°.

In a normal fermentation, which usually lasts about 24—30 hours, the acidity of the mash gradually increases from a very small value until 10 cc. of the mash liquor requires from 3·5 to 4·5 cc. of 0·1 N *sodium hydroxide* solution for neutralisation, after eliminating carbon dioxide. Usually 13 to 17 hours are required before the acidity reaches its maximum value, when the formation of acetone and *n*-butyl alcohol commences. The actual value for the maximum acidity and the interval before the *n*-butyl alcohol and acetone are formed, depends to some extent on the experimental conditions, the source of carbohydrate, and the percentage of inoculant. During the production of acetone and *n*-butyl alcohol in the mash, the acidity falls gradually to a constant value of about 1·5—2·5 cc. of 0·1 N-sodium hydroxide per 10 cc. of mash. It was considered that, in view of these variations, a study of the acid-formation in the fermenting mash might give an insight into the fermentation process.

* Read before the British Association (Section B), Bournemouth Meeting, 1919.

The acids present in the mash are principally acetic and butyric acids with a small quantity of a non volatile acid. It is found that the ratio of these acids to each other depends on the age of the fermentation. Shortly after inoculating, the acids are present in the proportions of approximately 4 or 5 molecules of acetic acid to one of butyric acid, but as the acidity increases, the ratio of acetic acid to butyric falls, until at the period of maximum acidity there are about 1·1 to 1·4 molecular proportions of butyric acid to one of acetic acid. During the production of the acetone and alcohol the ratio of acetic to butyric acid increases gradually, so that, when the fermentation is completed, the volatile acids in the mash are 4 or 5 parts of acetic acid and one part of butyric acid.

The fluctuations in the relative amounts of the two acids present in the mash would indicate that the acids are intimately connected with the production of acetone and *n*-butyl alcohol, especially as the formation of the latter substances may be suppressed almost completely by conducting a fermentation in presence of calcium carbonate. Under these conditions the main products formed are acetic and butyric acids. These acids have been obtained in the ratio of ten molecules of acetic to nine molecules of butyric. Using these proportions, and assuming that *n*-butyl alcohol and acetone are formed from the acids without any appreciable side reactions, *n*-butyl alcohol and acetone should be produced in the ratio of 2·3 parts by weight of the former to one of the latter. Such a result is in accordance with the actual yields obtained. It seems likely, therefore, that the *n*-butyl alcohol is produced from the butyric acid. In support of such a view, several facts are adduced; the decrease of the amount of butyric acid in the mash is coincident with the formation of *n*-butyl alcohol; the hypothesis is in agreement with experimental data given by Buchner and Meisenheimer (*Ber.*, 1908, xli., 1410); the reduction of butyric acid to butyraldehyde has been observed to be brought about by certain extracts; the addition of butyric and propionic acids results in the formation of *n*-butyl and *n*-propyl alcohols respectively; *n*-butyric acid has been observed in most fermentations in which *n*-butyl alcohol is obtained.

It is also probable that the acetic acid is an intermediate substance in the formation of the acetone, since the decrease in the amount of this acid in the mash during the fermentation is much slower than that of butyric acid. The amount of acetone produced is only half that of the alcohol. Also on adding acetic acid to the fermenting mash it is found that the added acid is converted principally into acetone. The fatty acid is best added periodically some hours after the maximum acidity of the mash has been reached, in such a manner as to maintain a figure for the acidity of the mash equal to the maximum acidity obtained in a normal fermentation.

There is produced also in the fermentation a small amount of ethyl alcohol. It is not yet determined whether this is obtained in a side reaction, or whether it is due to the presence of some impurity.

The two volatile fatty acids in the mash appear to be attacked, each in a different manner, the butyric acid undergoing a reducing action, while the acetic acid is condensed to acetone. To account for this difference, it is suggested that the formation of dipropyl ketone by condensation from the butyric acid may be prevented owing to the increased steric hindrance imposed by the presence of large groups.

The Treasury announce that applications for permission under the Defence of the Realm Regulation 30 F. to raise capital in this country, where the proceeds of the issue are to be applied for capital purposes outside the United Kingdom, will in future be dealt with by the Board of Trade. All communications with regard to either new or pending applications should be addressed to the Secretary, Capital Issues Committee, Board of Trade, Gwydyr House, Whitehall, London, S.W. 1.

CORRESPONDENCE.

LOAN OF MAGNETIC SCLEROMETER.

To the Editor of the Chemical News.

Sir,—The new Magnetic Sclerometer has aroused great interest among the Universities and Technical Schools, and we have received many applications for the loan of an instrument.

Wishing to lend every possible assistance to laboratory research and demonstration, we have decided to lend an apparatus, complete with samples of different steels having varying heat treatments. This apparatus will be on loan, for short periods, for purposes of demonstration, and will be supplied to recognised educational authorities upon receipt of an application from Principals or Senior Demonstrators.—We are, &c.,

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NOTES.

Commercial Exchange at Groningen.—Some time ago a Committee was formed at Groningen for the purpose of establishing a Commercial Exchange for the general wholesale trade. This, states the British Consul at Groningen, opened on Thursday, September 4, and will continue every Thursday from 12 to 3 o'clock. The Town Council has on certain conditions granted the use of the Corn Exchange for this purpose. It is understood that the Exchange will be divided into several departments, of which the most prominent will be—Money; Insurance and Transport; Coffee; Tea; Tobacco and Cigars; Oils, Fats, and Packed Meat; Building Material; Wines and Spirits; Leather and Hides; Potato Flour and Strawboard; Grain, Seeds, Beans, and Peas; Ironmongery, Machinery, and Paints; Drugs and Chemicals; Textile Goods and Confectionery. The Committee has communicated with the Passport Office at The Hague and with several Dutch Consuls in Germany requesting them to facilitate the visits of German merchants.

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Botanical Gardens. About 8·7 per cent of the total native flora of 709 species is regarded as endemic.

To supplement Hooker's great "Flora of British India," the second part of Gamble's "Flora of Madras" appeared last year. Duthie's "Flora of the Gangetic Plain" is still in hand. Of Maiden's comprehensive monograph "A Critical Revision of the Genus Eucalyptus," thirty-five parts, comprising 181 species, have so far been issued.

Digressing for the moment, I would mention that British Guiana, with an area equal to that of Great Britain, on the mainland of South America, is full of interest, but its rich and abundant flora, extending from an extensive coast line to the high lands of the interior, with the Kaieteur falls and the remarkable Roraima Mountain rising to over 8000 feet, is little known to the world at large. There is also the fertile and easily accessible island of Trinidad, at the mouth of the Orinoco, which has been a British Colony for more than a hundred years. Although the necessary material is conveniently at hand in the local herbaria, brought together with great care during the last thirty years, neither of these portions of the Empire has, as yet, published a handy working flora from which their special botanical and economical resources might be ascertained. In these days a systematic exploration of our tropical possessions and the publication of the results in an accessible form should serve as the first step in their fuller development.

Of interest from another point of view is a new supplement of "Index Kewensis," now ready for the press. This invaluable work of reference was originally prepared at the urgent request of Darwin, who undertook the cost of producing it. The Bentham Trustees have lately issued a complete index to the plates and names of plants that appear in the thirty volumes of "Hooker's Icones Plantarum."

Further, it is worthy of note that the Royal Horticultural Society is arranging, with the help of Kew and the British Museum (Natural History), to undertake to bring out a new edition of Pritzel's "Iconum Botanicorum Index." The original work, indispensable to a botanical and horticultural library, contained 107,000 entries. It is estimated that, at least, an additional 125,000 references will appear in the new edition.

This may be an appropriate occasion to refer to the new branch of botany which has lately come into prominence as one of the results of the devotion to nature study and the contemplation of the characteristic features of vegetation as we find it distributed over the earth's surface. Ecology is capable of enormously extending the outlook of botany, and it has so largely added to the interest of field work that we may wonder that the phenomenon of vegetation so long displayed before our eyes had not suggested its sociological aspects long ago. Ecology has its Society and Journal, and it bids fair to fully establish itself in the household of botany. It is hoped it will mitigate some of the admitted drawbacks of purely laboratory work and revive the old Natural History spirit of former days. As pointed out by Thiselton-Dyer, it is to this spirit that we owe the Darwinian theory which rested on every point on a copious basis of fact and observation made in field and forest.

In describing the principal forms of plant communities the first requisite is to become familiar with the species and their distribution in relation to their habitat. This neighbourhood is noteworthy for the opportunities it offers for the study of the natural vegetation of calcareous soils, of the heathlands of the Bagshot sands, as well as of an interesting series of aquatic and marsh plants. The presence of many of the Southern elements of the British flora enumerated by Stapf is also of interest. Among these, to mention a few, are *Simethis bicolor*, *Lotus hispida*, *Gladiolus illyricus*, *Ludwigia palustris*, *Lobelia urens*, *Erica ciliaris*, and *Pinguicula lusitanica*.

The phenomenal spread of a comparatively new marsh grass (*Spartina Townsendii*) along certain portions of the South Coast deserves careful study. It is supposed to be a hybrid between *S. stricta* and *S. alternifolia*. It is claimed to be pre-eminent among halophytes on account of the extraordinary vigour with which it spreads over mud flats and eventually forms meadows to be measured by thousands of acres in the neighbourhood of Southampton Water and Poole Harbour. It is a question whether it may not develop into a serious menace to navigable waters. On the other hand, it may prove capable of being utilised in suitable localities as a reclaiming agent. Its economic value in providing material for paper-making or as food for cattle may also receive attention. It is unnecessary to enter into further details, as Prof. Oliver, who has kept this grass under observation for many years, has kindly consented to give an address summarising the results.

The critical study of British plants was supposed to be an exhausted field, but with the necessary insight and careful and critical observation there is much work still to be done. Exchange clubs are active, and additions to local floras are continually being made. New species, varieties, and hybrids are published from time to time. As an instance, *Potamogeton upsaliensis*, hitherto only known in Sweden, has recently been found in this neighbourhood. Hybrid orchids are being keenly studied, and the occurrence of hybrids in this and other classes of plants opens a wide and interesting field of investigation.

A much-desired piece of work is a continuance of Starkie Gardner's interesting investigation of the fossil flora of the Bagshot beds so well shown in the Bournemouth and adjoining cliffs. Some of these have proved exceptionally rich in remains of tropical and sub-tropical plants. Among the genera claimed to be represented are *Acacia*, *Smilax*, *Lygodium*, *Gleichenia*, *Myrica*, *Eucalyptus*, *Araucaria*, *Diospyros*, *Nipadites*, *Sequoia*, and a palm (Iriartea), now only found in tropical America. So far, in regard to these plant remains, we may say with La Place: "What we know is but little; what we do not know is immense."

After an interval unprecedented in the history of the British Association we meet once more under its high authority so that the leaders in science and men of affairs with wide and deep experience may take counsel together and discuss the latest results of scientific investigations. We have everything to gain from a free exchange of experience and ideas. This is a time when science does well to renew its touch with daily life both for its own sake no less than for the sake of true progress. It is recognised that the enormous advance in the material comfort and the prosperity of our race during the last century has been due to the application of science. Nevertheless, in the newer times which we are now entering upon we shall require all our energy and all available scientific knowledge to win through to success. It is encouraging to realise that since we met at Newcastle in 1916 there has been a truly remarkable progress in every branch of science. Also, a fuller recognition of the value of science and education as means whereby the material interests of the world may be enlarged.

My distinguised predecessor, whose work has been largely concerned with the systematic and philosophical side of Botany, has rightly expressed the general desire for a more cordial understanding between botany and its economic applications. "It is certain," he said, "that our outlook must be widely different after the war, and the changed environment must find us ready to respond in the interest of our country and mankind."

With your permission, and acting on a suggestion made by my Committee, I propose to travel a little outside the usual scope of previous addresses and review the many efforts that have been made, and are still being made, to promote the interests not only of the home land but of the Empire as a whole. My own activities have been more or less intimately connected with the Tropics. Their productions are daily in increasing demand, and are becoming more and more necessary to the inhabitants of temperate countries. Before the war it was estimated there were about three million square miles of British

territory within the tropical zone. A portion of this area, including India, was already producing commodities of the estimated value of 230 million sterling.

It is, therefore, in the national interest to keep closely in touch with the conditions and prospects of our tropical possessions, in order that we may render them still more capable of supplying the raw material so necessary to the maintenance of our commercial prosperity.

In recent times one of the most important steps taken in this connection was the establishment, on the recommendation of a Royal Commission, appointed by Mr. Joseph Chamberlain, of an Imperial Department of Agriculture in the West Indies. The provision for the upkeep of the Department, approved by Parliament, was at the rate of £17,400 per annum. From the first special efforts were made to bring the resources of science to bear on all matters relating to the welfare of the Colonies concerned. The laboratories and the headquarters of the Department were established at Barbados, together with a staff of University men with special qualifications for research. The latter carried on their work in co-operation with officers of a like standing at British Guiana, Trinidad, and Jamaica.

When fully organised the Department made grants for teaching science at colleges and secondary schools, and for the maintenance of agricultural schools, botanic gardens, and experiment stations. Special attention was devoted to research work in raising new varieties of sugar-canes and other plants, in the investigation of diseases affecting crops, and the general amelioration of the conditions under which they were grown. Further, by means of an efficient staff of travelling agricultural instructors and an abundant supply of literature the Department was brought into intimate touch with all classes of the community. At the end of ten years of strenuous effort it was noticeable, owing to the expansion and improvement of old industries and the introduction of new industries, the general conditions in the West Indies were greatly improved. This may be illustrated by the fact that the public revenue of the Colonies had increased from £2,546 724 in 1894 to £3,914,434 in 1911, while the total trade during the same period had increased from £16,270,474 to £26,949,086. There was thus an increase of 65 per cent in the total revenue and of 60·5 per cent in the total trade. In reviewing the situation in the West Indies, as the result of the activities of the Imperial Department of Agriculture, and those associated with it, the late Prime Minister said "the work of the Department was universally and gratefully acknowledged by the planters to be largely responsible for the improved state of affairs in all branches of agriculture, and he believed —and he spoke with some experience—it would be difficult to find a case in which any analogous experiment made by the Home Government had attained such speedy and satisfactory results."

A gratifying proof of the value of the work of the Imperial Department of Agriculture in the West Indies was the formation of several departments on similar lines, first at Pusa in India in 1902, and subsequently in all the tropical Colonies in the New and Old World. Further, twenty competent officers trained in the West Indies are now in charge of Departments of Agriculture in Ceylon, Mauritius, Federated Malay States, Fiji, and on the staffs of the Imperial Department of Agriculture in India and the several Colonies in East and West Africa. Another interesting feature of West Indian progress was the wider appreciation of improved methods of cultivation and the value of science by members of the planting-community. For instance, in 1898 the aggregate amount voted by the local legislatures for staffs, laboratories, and botanic and experiment stations was at the rate of £14,000 per annum. Apart from the funds of the Imperial Department of Agriculture, it is probable that, directly or indirectly, the total amount contributed locally for scientific services is now not less than £60,000 per annum. It is also to be noted that during approximately the same period the number of scientific and technical officers had increased from 67 to 142. This, however, is not confined to the West Indies, for in a list, published annually at Kew, the number of scientific officers attached to botanical establishments in various parts of the Empire had increased from 122 in 1892 to 332 in 1918.

There can be no doubt that not only in the West Indies but in all parts of the Empire "enlightenment as to the objects, methods, and the conditions of scientific research is proceeding at a rapid rate." A review of the circumstances relating to all the Overseas Dominions would be a task entirely beyond my province. Perhaps the most interesting feature of the progress made is in connection with the application of the laws of heredity to the improvement of such highly important crops as sugar, wheat, and cotton. The problems associated with these involve both scientific and economic considerations. As regards the scientific side, it is fortunate that with the beginning of the twentieth century came the rediscovery of Mendel's facts and the stimulating energy of the genetic school which has brought us an entirely new point of view in regard to the improvement of field crops.

Great importance is attached to the improvement of the sugar-cane, as the prosperity of many of our possessions depends upon it. Further, the requirements of this country approach something like two million tons per annum. The sugar-cane, although its origin is unknown, has been cultivated in tropical and sub-tropical countries from remote ages. Up to a recent date its propagation was purely vegetative, as it was supposed to have lost the power of producing mature seed. Occasionally by bud variation a new cane was obtained possessing special merit. For instance, at Barbados in 1903 a "sport" cane cultivated under normal conditions yielded at the rate of 8070 pounds of sugar per acre as compared with 6228 pounds yielded by the original cane. In Java, where the white Cheribon was practically the only kind grown, a red cane suddenly appeared. This was carefully multiplied by cuttings until a large area was planted, with the result that a greater tonnage of canes was raised per acre and the juice was richer.

Sugar-cane seedlings were observed at Barbados in 1858, but it was only in 1888 that Bovell and Harrison were in a position to utilise the discovery and obtain thousands of self-sown seedlings for experiment purposes. Similar seedlings were also available in Java about the same time. As about this period the standard canes in sugar-growing countries were showing signs of being severely attacked by disease the discovery of seedlings was a fortunate circumstance. In fact, in some cases it may be regarded as having probably saved the industry. A careful examination of the floral characters of the best varieties of sugar-canes disclosed the fact that in some cases the ovary was normal while the stamens were infertile. Advantage was taken of this circumstance to secure cross fertilisation by planting selected canes of each type in alternate rows. By this and other means, skilfully devised, several varieties of sugar-canes of great merit were raised.

The possibility of breeding sugar-canes by cross fertilisation under control on Mendelian lines has so far not proved practicable. Partly on account of the enormous number of florets in the panicles and their microscopic character, but chiefly owing to the difficulty of manipulation in the field. Lewton Brain and Stockdale made careful experiments in 1903 and 1905, but the results in both cases were disappointing. In spite of this a large number of seedling canes have been raised in cases where the seed-bearing parent only was known. In others neither parent was known. The results, on the whole, have not been unsatisfactory. Seedling canes in many cases have taken the place of the older varieties, while larger returns per acre have been obtained. Further, owing to careful selection there has been a marked diminution in the losses from the attacks of insect and fungoid pests.

In British Guiana it is reported that in the crop of 1918 seedling canes occupied 83 per cent of the total areas under canes. Similar results have been obtained ar Barbados, where Bovell has continued since 1888 in raising canes of great merit. Also in the Leeward Islands, and more or less in Trinidad and Jamaica. The best of the West Indian seedlings have been widely distributed to other countries. The general policy adopted by Harrison in British Guiana as the result of over thirty years' experience in cane selection is briefly summarised as follows :—"We raise as many seedlings as we can from varieties of proved vegetative vigour, and select from those having both well-marked vegetative vigour and relatively high saccharine content." He adds—"The characteristics of seedling canes are not fixed, and in many instances characteristics which in earlier years promised to make a cane of high quality, both in the factory and field, were the first to fail." Harrison's experience suggests a special line of research, viz., to ascertain the cause of the increase in vegetative vigour and yield that follows a first cross, only to disappear in later stages.

In India there is probably a larger area under sugar-cane than in any other country. Its production of sugar is over two million tons. The larger proportion of this consists of a low-grade quality known as jaggery or *gur*. Palm-sugar is also produced to the extent of half-a-million tons. The sugar-producing areas in India consist of two main portions—A southern portion in Madras, Mysore, and Bombay wholly within the Tropics, and a northern portion outside the Tropics extending from Assam to the Punjab, a distance of one thousand miles. The difference in soil and atmospheric conditions has a marked influence on the character of the canes grown in the two regions. In Southern India the canes are stout and usually as productive in the irrigated areas as in other tropical countries; but in the North the canes are more slender, grown in thick clumps, and owing to the high percentage of fibre are much less productive in sugar.

Speaking generally, the sugar industry in India is not in a satisfactory condition. In spite of the enormous area under cultivation India is obliged to increase its considerable imports of sugar from Java and other countries. To obviate this urgent steps are being taken to improve the character of the canes and establish varieties adapted to local conditions and the circumstances of the sugar growers. The latter are almost entirely of the peasant class or rayats. At first it was sought to introduce better varieties of canes from other countries. A sugar station was established for this purpose at Samalkola. It was soon evident that the luxuriant canes of the Tropics were not suited to the special conditions existing in Northern India. What was needed was a more hardy type of cane capable of holding its own under the field conditions and the resources of the cultivators. To obtain these they had to be produced in India. With this object in view a cane-breeding research station was established in 1910 at Coimbatore, with Barber, an experienced scientific man, in charge. The locality was regarded as favourable because canes were known to flower there comparatively freely. At first the improvement of local canes by selection and later by seedlings from parents of known vigour and high saccharine quality received attention.

In raising seedling canes the chief difficulty was the irregular flowering of the best canes. Barber arrived at the conclusion that until some control of the flowering is obtained work on Mendelian lines was not practicable. In spite of this a large number of selected seedlings are now being raised at the rate of 4000 per annum. Some of these, lately distributed to the experiment stations in Northern India, have been reported upon as "entirely satisfactory."

Much more still remains to be done, but there is reasonable hope that a race of superior hybrid seedlings will be produced that will eventually displace the inferior local varieties hitherto cultivated. To ensure even moderate success in this direction it is recognised that the work of cane-breeding must never slacken, and further that the means of distribution and the number of stations and capable workers must be increased.

In the considerable literature of sugar-cane breeding in India Barber has brought together a vast amount of information of singular interest and value. In the few years that have elapsed since he has been in charge of the Coimbatore Research Station he has laid the foundation of lines of inquiry that cannot fail to prove of great value in the permanent improvement of the sugar industry in India. It is a good augury as regards the future that the Government of India has lately formed an Imperial Sugar Bureau, whose duty it is to collect and collate the scattered results obtained in various directions and keep closely in touch with the sugar work done in India and in other sugar-producing countries.

In his Presidential address in 1898 Sir William Crookes stated that the prime factor in wheat production was a sufficient supply of nitrogen. As the supply was then showing signs of exhaustion he warned wheat growers of the peril awaiting them. Sir R. H. Rew has now shown that, thanks to the chemist, who came to the rescue, there is practically no limit to the resources of nitrogen. What he hoped for was that the future would see not only a larger acreage in this country under wheat but also a substantial increase in the average yield. During the great war the British people have realised under the stress of a fight for existence that the question of food supply is the most vital of all national interests. Both in this country and in India and in the Overseas Dominions great progress is being made in raising new varieties of wheat yielding large returns per acre and possessing excellent milling and baking qualities. In the pre-Mendelian days excellent work was done in wheat breeding by Saunders in Canada and Farrer in New South Wales. Their work proved of enormous benefit, as it not only provided varieties of superb quality, but also those that could be successfully grown in districts where wheat growing for various reasons was previously impossible. During recent years Biffen by his successful investigations on Mendelian lines at the Plant Breeding Institute at Cambridge has shown that the characteristics distinguishing the numerous wheats can be traced, and the building up of a fresh combination of these characters was possible on practical lines. As the losses caused by disease were so serious, sometimes running to millions of quarters annually, Biffen devoted special attention to the possibility of breeding rust-resisting varieties. He found that the power of resisting the attacks of yellow rust, for instance, was an inheritable character. By crossing "Gurka," a Russian disease-resisting wheat, with Square Head's Master, one of the most wide cultivated wheats in this country, Biffen eventually produced "Little Joss," which, after trials extending over a period of several years, is said to yield four bushels per acre more than any other variety. Further, it possesses distinct disease-resisting qualities.

Another of Biffen's new wheats is "Yeoman." This was raised in order to produce what are known as strong wheats. These are in great demand in this country, as they produce a flour which is much superior for baking purposes to the flour of English wheat. In pre-war days Canadian strong wheats commanded in the market 5s. more per quarter than the best English wheat. "Yeoman" not only possesses the superior quality of Canadian wheat but combines with it the high-yielding character of certain English wheats.

A well authenticated report, supplemented with full details, of the value of "Yeoman" as a field crop was lately published (*Journ. Bd. Agric.*, xxv., 1161). It was cultivated under normal conditions, but without artificial manure, on three fields on a large farm near Wye, Kent. The cropped area was a little over twenty-seven acres. The total yield was 2072 bushels, or an average of about seventy-seven bushels per acre. One field, previously under beet, comprising three acres two rods and eight poles, yielded 340 bushels, or an average of eighty-six

bushels per acre. These results may be compared with thirty-two bushels, the average yield of wheat in this country.

Further, in another variety known as "Fenman," Biffen has produced a wheat with a short, stiff straw for the Fen country. This is able to withstand the usual tendency of the ordinary sorts to grow tall and be beaten down and injured in rainy seasons. A most desirable improvement in wheat growing in this country is to obtain a spring wheat combining early maturity with a yield approaching that of winter wheat. There is likely to be a difficulty in securing these most desirable results, but what Biffen has already achieved in dealing with qualitative and quantitative characters offers fair promise of success. The establishment of a National Institute of Agricultural Botany for the further development of plant breeding and the distribution of pure seed may be regarded as essential to the welfare and safety of the nation.

Wheat growing is a very important industry in India. It was estimated in 1906-7 that twenty-nine million acres were under cultivation in wheat with a yield of nearly nine million tons. Of this 90 per cent was consumed in India. A botanical survey of the Indian wheats was undertaken by the Economic Botanists at the Imperial Research Institute at Pusa in 1910. In the following years by the application of modern methods of selection and hybridisation high-grain qualities were successfully combined with high yielding power, rust-resistance, and stiff straw, so that wheats were produce which gave upwards of forty-one bushels per acre.

Among the best of the new varieties are Pusa 4 and Pusa 12. Owing to an organised system of distribution of seed it is estimated that the area under Pusa 12 during the last wheat season (1918-19) was about 400,000 acres. The area under Pusa 4 was about 100,000 acres. The increase yield of 25 per cent over the varieties formerly grown in India as well as 1s. per quarter more on the market, owing to the improved quality of the grain, are factors of great value as regards the future of wheat growing in India. Pusa 4 and 12 are said to possess the added advantage of being able to mature with less water than the ordinary Indian wheats.

The important work carried on at Pusa by Howard and his accomplished wife has followed closely on the methods found so successful at Cambridge. It is interesting to note that in obtaining new kinds by hybridisation between Indian wheats and rust-resisting forms in Northern Europe a difficulty in regard to flowering at different periods was overcome by sending the Indian parents to Cambridge for spring sowing and by carrying out the actual crossing with Biffen's new hybrids in England. From the crosses thus obtained Howard reports that a wide range of wheats has been evolved likely to prove superior to Pusa 4 and Pusa 12.

The admirable work done by Biffen at Cambridge and the Howards in India clearly demonstrates the value of thorough acquaintance with pure botany as a qualification for grappling with questions of economic importance.

In reviewing the gains to Indian wheat growers the Director of the Agricultural Research Institute has recently stated that in view of the favour with which the new wheats have been received and the cordial co-operation of provincial organisations "it is a modest estimate to assume that in the course of a very few years the area under Pusa wheats will reach five million acres. This means an increase in the near future in the value of the agricultural produce of India, in one crop only, of 75 lakhs of rupees or five millions sterling." Another crop that has received attention is indigo. In regard to this a new method of growing the seed has been worked out, and the cause of the destructive wilt disease has been traced to the destruction of the fine roots and nodules during the monsoon rains. The remedy in this case is the selection of surface-rooted plants which are now in course of being generally grown.

(To be continued).

STUDY OF *n*-BUTYL SUBSTITUTION IN THE ARYLAMINES.*

By JOSEPH REILLY, M.A., D Sc.,
and
WILFRED J. HICKINBOTTOM.

The *n*-butyl substituted arylamines have been investigated hitherto to a very limited extent, probably because *n*-butyl alcohol has been available only in small quantities. Now that it is possible to obtain this alcohol in large amounts, its utilisation, industrially, in the preparation of dye-stuffs and other technical organic compounds, is a matter for consideration. It also has been observed that the *p*-nitroso derivatives of the higher alkylanilines have marked physiological properties.

The simplest *n*-butylarylamine is *n*-butylaniline, which has previously been obtained as a by-product only in the condensation of *n*-butyraldehyde with aniline (Kahn, *Ber.*, 1885, xviii., 3361). The preparation of *p*-nitrosodibutylaniline and *p*-phenylene di-butyldiamine was unsuccessfully attempted by Karrer (*Ber.*, 1915. xlviii., 1393). He claimed that the di-butyl and diamylanilines acted differently from the lower alkylanilines.

It is therefore of interest to carry out a more detailed examination of these *n*-butyl derivatives. When *n*-butyl chloride and aniline were heated under reflux a mixture of mono- and di-butyl anilines was obtained. From the mono-*n*-butylaniline the *p*-nitroso derivative was obtained, which yielded, on reduction, the corresponding phenylenediamine. *as*-Phenyl-*n*-butylhydrazine was also prepared, and from it diphenyl-di-*n*-butyltetrazone. The latter compound is characterised by a series of colour changes on standing in presence of aqueous alcohol. Di-*n*-butylaniline gave a liquid *p*-nitroso compound which yielded a number of addition compounds with metallic salts. Reduction of *p*-nitroso-di-*n*-butylaniline gave *p*-phenylene-di-*n*-butyldiamine, identical with the diamine obtained by reducing the azo compound formed by coupling diazotised sulphanilic acid with di-*n*-butylaniline in acetic acid solution. This result is at variance with those of Karrer.

The *n*-butyl-*o*- and *p*-toluidines were prepared similarly to the *n*-butylanilines, but in this case it was observed that di-*n*-butyl-*o*-toluidine could not be obtained by the action of *n*-butyl chloride on mono-*n*-butyl-*o*-toluidine, while *p*-toluidine yielded both mono- and di-butyl substitution products. Mono-*n*-butyltoluidine on nitration in presence of an excess of concentrated sulphuric acid yielded 2-nitro-*n*-butyl-*p*-toluidine, which on further vigorous nitration gave 2 : 3 : 5-trinitro-*n*-butyl-*p*-tolylnitramine. Nitration of *n*-butyl-*p*-toluidine yielded successively 3-nitro-*p*-toluidine, 3 : 5-dinitro-*n*-butyl-*p*-toluidine, and the nitroso and the nitramino derivatives of the above compound. With the latter two compounds, various experiments were carried out on the elimination of the nitroso and nitramino groups. It was shown that boiling alcohols and sunlight are able to remove these two groups.

A study was made of the formation of the *n*-butylarylamines by condensation of the alcohol with the amine in the presende of hydrochloric acid or a similar condensing agent. It was found that by carrying out the reaction at 200° appreciable amounts of a primary amine were obtained, and its presence was ascertained to be due to the intramolecular change of the *n*-butylaniline. This compound has been proved to be 4-amino-*n*-butylbenzene. A study of the literature revealed the fact that it is probable that *iso*-butylaniline yields 4-*amino-tert*-butylbenzene on heating with hydrochloric acid in a sealed tube, so that there is a difference in the behaviour of the two butylanilines. *sec*-Butylaniline undergoes intramolcular rearrangement in a normal manner, yielding 4-amino-*sec*-butylbenzene.

In certain of the substances containing a *n*-butyl group

* Read before the British Association (Section B), Bournemouth Meeting, 1919.

attached to the aminic nitrogen the colour of the compound differs from that of the corresponding methyl or ethyl derivative produced. Certain dye-stuffs which have been prepared containing *n*-butyl groups also give different colours compared with the colour of the corresponding lower alkyl derivative. A detailed comparative study (absorption spectra, shade of dye on various materials, &c.) of dye-products of the *n*-butyl series would be of interest.

MAGNESITE.*

By W. C. PHALEN.

Raw Austrian magnesite contains iron in natural combination. That produced in the State of Washington has a much lower iron content, and before calcining 2½ per cent iron oxide in finely-divided condition is added to the ground and screened magnesite, and the mixture is then calcined at a high enough temperature to thoroughly sinter the iron oxide. The resulting product is as good as the Austrian in every way, and has been exclusively used by one of the principal American makers of magnesite refractories since the middle of 1918, nearly 60,000 tons having been used and marketed. About 10 per cent of the magnesite produced in this country is used to make magnesite flooring, or oxychloride cement, the manufacture of which began in the United States about twenty years ago in an experimental way, and for the past six or eight years has been commercially successful. When magnesite is calcined at a temperature of 1600° F. it produces caustic burned magnesite, which reacts with peculiar phenomena with a solution of magnesium chloride, producing, when in combination with fillers, a tough compact mass known as oxychloride or sorel cement. The resulting composition has strength sufficient to make a compact, resilent, and sanitary flooring which has extraordinary strength to withstand blows and rough wear, is tough enough to prevent the formation of cracks, and is impervious enough to withstand puncture. Unlike Portland cement it is possible to saw, cut, and insert screws into it. The product also possesses fire resistance and heat insulation. It has, therefore, been found useful in monolithic floors, in stucco, and slabs, for insulation and pipe covering, for the decks of ships, the floors of freight and Pullman cars, hospitals, &c. Its cost is slightly in excess of foundation cement, but well within the cost of other permanent floorings, such as tile, &c.—*Journal of the Franklin Institute*, September, 1919.

METALLURGY OF WULFENITE.*

By J. P. BONARDI.

Probably 90 per cent of the molybdenum produced in the United States during the war period was derived from molybdenite, in spite of the fact that prior to 1915 the wulfenite ores of Arizona supplied the larger part of the molybdenum. This is because of the successful application of flotation to molybdenite and because the deposits of the latter are larger. The wet concentration of wulfenite ore offers little difficulty, but a number of associated minerals—vanadinite, cerussite, anglesite, galena, pyromorphite, and mimetite—come out in the concentrate, rendering its subsequent treatment somewhat difficult. Usually a concentrate of 15 to 20 per cent MoO_3 is the best that can be obtained, and buyers of concentrate frequently set the latter figure as their minimum content. Wulfenite has the advantage over molybdenite that it frequently has gold associated with it, and both this and the lead are recovered in the treatment of the concentrate. Any of three methods may be used:—(1) An acid leach; (2) an alkaline leach; (3) fusing with something that will reduce the lead to the metallic form and take the molybdenum into the slag. The first has so many disadvantages compared with the other two as not to merit much consideration. Of the various alkalis, sodium sulphide is, perhaps, the most satisfactory, as the molybdenum goes into solution as sodium molybdate, while the lead and precious metals remain in the residues. This process is used by at least one company in the United States at the present time. The high-grade calcium molybdate thus produced can be used for the production of ammonium molybdate, ferro-molybdenum, or added directly to the steel in the manufacture of alloy steels. By fusing with soda-ash, caustic soda, and coal, the lead is recovered in the form of bullion. The sodium molybdate thus formed can be leached from the slag, and the metal precipitated in the form of calcium molybdate, which can be utilised as stated above. In one of the experiments a recovery of 96·7 per cent was made on the molybdenum and of 98·5 per cent on the lead, and it is estimated that a 90 per cent extraction of both would represent commercial practice. At present prices there is a difference of 270 dols. between the value of the products and the cost of the chemicals in treating a ton of typical concentrate, so that the process would seem commercially feasible.—*Journal of the Franklin Institute*, September, 1919.

* Notes from the U.S. Bureau of Mines.

ANNUAL REPORT OF THE COMMITTEE OF THE PRIVY COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH FOR 1918-19.

(Précis).

This fourth annual report of the Department of Scientific and Industrial Research gives some account of the work of this Department during the very abnormal year of the change from war to peace. Other Government Departments have had previous experience of peace conditions; this was established in the troubled times of 1915, and has laid upon it the onerous duty of seeing that problems arising in our industries and in other phases of our national life receive systematic scientific investigation.

For the State to enter upon the task of ensuring that its own action in dealing with problems affecting directly the well-being of large sections of its people is based upon full and exact knowledge gained by the methods of physical and biological science was a new development of its activities; and accordingly it was necessary to devise new machinery for the exercise of these activities. The plan adopted was to appoint a body of eminent men of science to act as permanent advisers to a responsible Minister. In this way the Advisory Council came into existence. This body is responsible for advising the Minister on the general scientific policy of the Department, and is in close touch not only with the administrative officers of the Department but also, through assessors, with the other Departments of State.

The work of the Department as described in the Report falls into three main divisions—(*a*) the progress made in the establishment of Research Associations, (*b*) the organisation of research for national purposes, and (*c*) the developments that have taken place in the conduct of researches initiated either by other bodies or by individual workers.

As regards the formation of Research Associations dealt with in Part I. of the report, it is estimated that the number of these will ultimately be about forty; of these seventeen have now been "approved" by the Department, though the necessary legal formalities have been completed in the case of nine only.

With the signing of the armistice in November last it became possible to modify the necessarily stringent conditions relating to the availability of the results of research which had been laid down during the war; accordingly, the conditions of grant were revised in January last to

make it clear that, subject to certain conditions, the ownership of the results of investigations conducted by Research Associations is vested in the Associations themselves.

The successful establishment of Research Associations has brought into prominence a number of new administrative problems, for whose solution the Department has sought the help of the Associations by calling the first of what is hoped will be a series of periodical conferences with representatives of Research organisations. At this conference such matters as the best methods of dealing with problems common to two or more Associations, the terms on which research workers should be employed, and the scope and organisation of a "Records Bureau" by the Department were considered.

Part II. of the Report deals with the increasing amount of research for national purposes. At the National Physical Laboratory the work undertaken for the War Departments has naturally diminished but the other Government work has grown. The testing of clinical thermometers is being carried out on a large scale, and the Electrical Standards Laboratory hitherto attached to the Board of Trade has been transferred to the National Physical Laboratory. Important researches on thermal questions having a bearing on industry, on methods of calculating lens systems, on lubricating oils, on ternary alloys, and on the form of Standard ships have been conduced. The main buildings of the Fuel Research Station at East Greenwich are now approaching completion, and the Fuel Research Board of the Department are reconsidering the whole question of research on the more economical use of fuel. A very important report on Gas Standards, which is likely to have far reaching effects on the economical use of coal, has been presented to the Board of Trade by the Fuel Research Board.

The work of the Food Investigation Board has increased enormously during the year, attention having been paid to the methods of preserving fish, meat, fruit, and vegetables, the transport of food stuffs in refrigerating cars and barges, and the increase of the use of edible oils and fats.

The Mine Rescue Apparatus Committee has continued its inquiries and has acquired much valuable knowledge.

The search for the means of recovering a greater proportion of tin from the ores of this metal has been continued by the Tin and Tungsten Research Board. Researches on oxygen and on gas cylinders have gone on steadily, and the Committee on Lubricants and Lubrication has carried its investigations to a further stage.

Considerable attention has been devoted to matters connected with the Housing question, work having been done on the testing and artificial seasoning of timber and on building materials; amongst the latter one of the most interesting is local material such as earth or chalk. In this connection it is worthy of note that if only one pound were saved on each of the new houses and cottages to be erected in this country, the result would more than defray the whole annual expenses of the Department, while the gain in wealth to the community through increased health would be incalculable.

Research has also been conducted for the authorities of the British Museum on technical problems connected with the preservation and restoration of objects in its keeping. The use of metal struts for aircraft and the best methods of making sound castings of brass and copper have also been the subjects of investigation.

The Industrial Fatigue Research Board, established jointly by the Medical Research Committee and the Department, has had increased demands made upon it as a result of the pressing need for knowledge to be made available for the State and for industry of the optimum conditions of physical labour of all kinds.

When it is taken into consideration that the whole of the work described in this part of the report is being carried on for the purposes of the State it is obvious that the time for the establishment of a definite scheme of scientific investigation for the ends of peace was quite ripe; indeed, it is quite safe to say that the nation has suffered incalculable losses through its omission to provide at an earlier date for the systematic collection of scientific knowledge on which to base its actions.

Part III. of the report is concerned with work undertaken by independent institutions aided by the Department or by individual workers or research students to whom grants are made.

It is probable that this work has not become so well known generally as that done in the establishment of research associations or in the carrying out of scientific investigation for State purposes, the reason for this being that it is in the main connected with what is, for want of a better term, often called "pure science."

Its value cannot, however, be over estimated, since the whole of industrial and other forms of applied research depend ultimately on researches in pure science. As Dr. Pottevin, who is now engaged in establishing a Department of Scientific and Industrial Research for the French Government, says, "It is incorrect to speak of pure science and applied science: there is only science and its applications." The term "pure science" is used by the Department as a convenient, though imperfect, means of defining the pursuit of knowledge for its own sake without any thought of its applications.

There is no more pressing problem before the Department than that of increasing the supply of trained, efficient research workers. If these are not found, and that speedily, the opportunity of placing British industry on a sound scientific basis will pass—with results whose evils cannot be foreseen. The whole movement towards the systematic and thorough investigation of industrial and other national problems is now full of promise, but if research falls into the hands of second rate men, through lack of supply of first-rate men, the British people, who for generations have proved themselves as being "practical," will feel disillusioned. We have in the past made great use of our capacity for using to the full a small stock of sound knowledge, and unless adequate means are forthcoming for increasing that knowledge and distributing it widely, we may remain contented to rely on this capacity which has so well served us in the past, and in an age of international competition the results of this would be national ruin.

The necessity for training research workers is therefore most urgent. During the last year the total number of grants made to research workers and students was 103 as compared with 67 in the previous year. Certain difficult questions relating to the availability of the results of research have been advanced towards solution, but that of patents for inventions made with State assistance, and especially of patents in countries overseas, is not yet settled, though progress is being made. The Department is not alone in finding the question of patents difficult, the American Government having encountered exactly the same obstacles. It is hoped, however, that shortly some device will be found to obviate the difficulties experienced. One provisional decision has been reached—that patents shall in no case be taken out for (*a*) inventions for the preservation of health or of life, *or* (*b*) inventions whose use can be enforced by a Government Department.

NOTES.

Conference of Employers and Employed.—The striking success of the three days Conference of Employers and Employed recently held in Birmingham by the Industrial League has encouraged them to extend their operations. Arrangements have been made to hold similar conferences in Glasgow, Newcastle, Manchester, Bristol, Portsmouth, and Sheffield, and negotiations are being conducted in other places. Subjects relating to labour

and commerce in all its various forms will be considered. One very important subject to be dealt with was suggested by Mr. J. R. Clynes, M.P., in the discussion on his paper at Birmingham on August 13. Mr. Clynes suggested that "The relation of Improved Labour Conditions in this Country, and Imported Sweated Goods," would be a subject on which the Industrial League could most usefully institute a conference. It is certain that a most interesting discussion would take place on this matter, and it will be included in the agenda of one or more of the conferences.

Ferro-concrete for Structures Exposed to Sea Water.—The Society of German Portland Cement Manufacturers, in collaboration with the Material Testing Bureau at Lichterfelde and the Hydraulic Works Inspection Department at Husum on the island of Sylt, have been experimenting for about twenty years in order to discover the most suitable mixture for concrete for sea-water structures. In this connection Dr. Gary has recently published a detailed report in a communication of the Material Testing Bureau, of which the conclusions are as follows:—In order to obtain suitably strong structures in sea water it is necessary to use cement which is as rich as possible in silicates, but poor in kaolin and iron oxide. Such cements, when at the same time they are rich in lime, can be considerably increased in value by adding certain quantities of trass. The decisive factor, however, for the permanence of concrete structures in the sea is the use of mixtures which are as dense as possible and impervious to sea water, while at the same time sufficient external hardening should be given to the substances before they are placed in the sea by exposing them to heat and to moist air. Concrete, the mortar of which contains more than 66⅔ per cent of sand, will generally not show the necessary density to enable it to stand attacks by sea water for any length of time. (*Mitteilungen des Reichsbundes Deutscher Technik*, No. 30, 1919.—*Technical Review*.

The Platinum Situation.—All commercial platinum is not pure metal; much use being made of iridium alloys. For electrical purposes platinum contains from 15 per cent to 50 per cent (average 25 per cent) of iridium, and for jewellery purposes 5 per cent to 10 per cent. Platinum may be replaced by palladium gold alloys for jewellery and dental work, rhodium is used for electrical pyrometers, and there are minor applications of osmium and ruthenium. Pure platinum is, however, required for the chemical industry for catalysers, in the manufacture of sulphuric acid and for the manufacture of nitric acid from ammonia. Asbestos or anhydrous magnesium sulphate, soaked in platinum chloride and subsequently baked to drive off the chlorine, forms the contact mass for contact acid plants, and fine platinum gauze is used for the catalyser in nitric acid plants. Platinum crucibles, dishes, tongs, triangles, and wire are required in every chemical laboratory. Tungsten, molybdenum, and nickel-chrome alloys are being tried as substitutes for platinum for electrical purposes, but they have not yet supplanted the latter metal. The non-essential use of the platinum metals in jewellery should be stopped. The platinum metals are, in general, obtained from placer mines, but small quantities have been obtained electrolytically. Platinum is geologically considered to definitely belong to the pyroxenite, peridotite, and dunite rocks. It is found in many places, but the total recoverable quantity can only be regarded as small. Allowing for war fluctuations it may be said that 90 per cent of the supply comes from Russia, perhaps 9 per cent from Canada, and 1 per cent from the rest of the world. The author deals in detail with the various platinum deposits of the world, and then discusses the economic features, controlling financial interests, and chief platinum refiners in Great Britain, the U.S., Germany, and France. It is thought that although Germany was well supplied with platinum at the outbreak of war, she is now probably short, which will handicap her in any very rapid extension of her chemical and electrical industries. At present Russian platinum mines are almost idle. The dredges are mostly not operating, and the industry disorganised. It will take months or years to get in full swing again, and the known deposits there are becoming exhausted. Colombia appears to have large reserves, and the Alaskan resources appear to be increasing. It is considered that the present price of 105 dols. per oz. is several times the value of the metal, but that the price will remain nearer 75 dols. than 50 dols. per oz. for several years to come. (J. M. Hill, U.S. *Geological* Survey, *Engineering and Mining Journal*, July 26, 1919).—*Technical Review*.

A New German Export Journal.—Announcement has been made of the publication of the *Deutsche Export-Revue*, which will appear in 14 languages, and will be published by Auslandsverlag, G.m.b.H., Berlin, S.W. 19, Kauenstr. 18-19. The object of the new journal will be "to maintain Germany's commerce and industry." At the same time the journal will be an official export organ of the Imperial German Industrial League and of the Leipzig Sample Fairs. The new journal will also absorb the old-established journal, *Das Echo*. It will appear eventually in German, Bulgarian, Chinese, English, French, Dutch, Italian, Japanese, Polish, Portuguese, Russian, Spanish, Turkish, and Hungarian. (*Stahl und Eisen*, August 7, 1919).—*Technical Review*.

Analytical and Works Chemist, just returned from War work (Chemicals) in States, British (English) born subject, aged 27, married, American University Graduate and training in General Commercial Chemistry (Oils, Foods, Chemicals, &c.), Minerals, Refractory Materials (Works experience on large scale), wants Position in any progressive concern where advancement will be possible by results.—Address, H. B, 64, Station Road, Blackpool.

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THE CHEMICAL NEWS
VOL. CXIX., No. 3105.

CHEMISTRY AND THE WAR.*

By Sir WILLIAM J. POPE, F.R.S.

THE sudden establishment of a state of war between two or more modern nations involves certain preliminaries. We may assume that the most peaceful of the great powers are in possession of carefully worked-out and detailed plans for necessary action in the event of attack by other similar powers; foremost in the elaboration of such plans are necessarily the data available as to the possibilities of success in any threatened war. We cannot imagine the gauntlet thrown down between several world-powers until the aggressor has made certain, so far as certainty is humanly possible, of ultimate victory. The equilibrium existing between all the relations, commercial, technical, and scientific, of modern life as between different nations is so complex and so delicate that its derangement by a condition of war must lead to results which cannot be foreseen; the dangers of the unforeseen may be minimised by certainty of success. Confidence in success can only be attained after years of consultation with the whole of the instructed talent of an Empire has indicated precisely the most favourable moment for aggressive action. War is too serious an enterprise to be embarked upon merely because it may seem desirable from some internal or external political motive; it can only be undertaken when its successful conclusion seems assured.

In these circumstances, we cannot doubt that one of the most important contributories to the recent war was the striking contrast between the material resources of Germany and of the rest of Europe. In no domain was this contrast more evident than in that of the chemical industries; no branch of scientific technology is more immediately concerned with the arts of war than that which includes all the great industries in which Chemistry takes a leading part. Let us review briefly the position of our chemical industries in 1914.

Germany was at this time in possession of well-established organisations for the manufacture of coal-tar colours; she provided the great bulk of the artificial dye-stuffs consumed throughout the world. Small installations existed in this country, France, and America, but the scale upon which operations were conducted outside Central Europe was insignificant. The outbreak of war was the signal for the conversion of all these great colour-making factories into manufactories of high explosive. The British demand for high explosive, the materials which form the bursting charge for shell, rose to about 1000 tons each of T.N.T. and picric acid and about 3000 tons of ammonium nitrate per week; the complex facilities for the manufacture of these enormous quantities of material were practically non-existent at the beginning of the war in this country, but Germany was in a position to meet all her military demands by a mere rearrangement of her coal-tar colour works. So lacking were our means for utilising the great source of toluene represented by coal-tar that, during the first year of the war, 80 per cent of our output of T.N.T. was derived from toluene contained in Borneo petroleum.

The British demand for cordite, which has for long constituted the standard propellant for both large and small projectiles, rose to about 2000 tons per week; the commencement of the war found us with neither works nor chemists for the manufacture of these quantities. We need not devote further time at present to the contemplation of the gigantic quantities of explosives needed during the war; they have been discussed in detail in the comprehensive Presidential address recently delivered by Prof. Henry Louis before the Society of Chemical Industry. A number of other important points arise which must have engaged the attention of the German authorities.

One of the chief essentials to a modern army or navy is quinine: 97 per cent of the world's quinine production comes from the Dutch colony of Java, and its import into Europe is practically under German control. A large number of other essential pharmaceutical products, such as salicylic acid, salvarsan, and local anæsthetics such as eucaine and novocaine, were made almost entirely in Germany. A war with Germany stopped our provision of all these essentials. Most of the fine photographic chemicals used in development and in the preparation of panchromatic plates were made almost exclusively in Germany; the initial lack of these constituted a heavy handicap to our air photographic service. Many of the essentials to the manufacture of special steels necessary to modern warfare, such as tungsten and the like, came to us from Germany.

It will be clear that the control which Germany had secured over the manufacture of such products as coal-tar colours, pharmaceutical chemicals, and the like, enabled her to throw her enemies into confusion by a purely economic method at the outbreak of war; this initial advantage was gained whilst entirely satisfactory arrangements were provided, by the stoppage of exports, for he, manufacture of the necessary quantities of explosivtes &c., at bome. Another advantage was, however, derived from the advanced development of the German chemical industries.

The fundamental essential in the manufacture of explosives is nitric acid or its salts; the rifle and the large gun would become useless if we were no longer able to obtain these substances. The world's supply of nitric acid salts has been hitherto obtained from the Chili saltpetre of South America; it is obvious that Germany could not go to war whilst dependent upon an oversea supply of this absolute necessity. It is known that previous to the war Germany was busily engaged upon the perfection of methods for manufacturing nitric acid and its salts from atmospheric nitrogen; this work came to a successful head in Germany not long before the outbreak of war, and she then became independent of oversea supplies of nitric acid. Is it to be doubted that this development of chemical industrial effort was not a factor in the declaration of war?

Whilst, during five years of war, this country succeeded in expanding its previously small installations for fine chemical manufacture to such an extent that they became of sufficient magnitude to meet the immense demands for military explosives, one essential difference is observable between the German practice and that initiated to fulfil corresponding war needs in this country. The German establishments were developed on a peace footing and produced materials consumed by the whole world; they paid heavy dividends and were a source of great national wealth in time of peace. At the same time they were available for mobilisation for war production of explosives at short notice. The whole world, in fact, paid for the erection and extension of the vast explosives factories which made Germany so formidable in 1914; the British Empire paid for the German munition factories just as it paid for Gretna. Now that war is over the German factories remain intact and can revert immediately to their former task of providing our Empire with dyes, pharmaceutical and photographic chemicals, &c., as a dividend-paying proposition. The great German synthetic nitrogen products works, developed so as to render Germany independent of sea-borne nitrates for explosives manufacture, will now produce a considerable proportion of the nitrates and ammonium salts needed by Europe as agricultural manure. During the war the German synthetic nitrogen products factories have been greatly extended; these

* A paper read before Section B of the British Association at Bournemouth on September 9, 1919.

extensions constitute a valuable asset to the German commerce of the near future.

In this country it has not been possible to build up a chemical manufacture for war purposes which can be at once diverted to production for peace requirements. Explosives factories have had to be put up hurriedly for war production alone; the organisation could not be developed at short notice in such a way that the factories acquired any considerable after-war value. Thus, the vast installation at Gretna is now practically on the scrap-heap. Whilst the German chemical industries emerge from the war in a stronger position than they held before, our own remain much where they were.

The causes which have placed the German chemical industry in the commanding position which it has so long occupied have been repeatedly discussed and need not be considered on the present occasion. One point, however, may be insisted upon. Germany has not secured supremacy in fine chemical manufacture by the command of any monopoly of scientific talent; in fact, a disproportionately large number of German technical products were discovered by scientific workers in Great Britain. A remarkable illustration of this fact occurs in connection with the materials which have been used in chemical warfare. Thus, phosgene was discovered by John Davy in 1812 (*Phil. Trans.*, 1812, 144), but only insignificant quantities had been made in this country; it was manufactured in considerable quantities in Germany for use in coal-tar colour preparation. The best and most economical methods of manufacture had been worked out on a peace basis in Germany; phosgene is an extremely poisonous substance, and was early used by the Germans in gas warfare. Large quantities of phosgene were used by us for the same purpose, but only after the delay caused by the necessity of time for working out the most convenient methods of manufacture and the construction of plant. Again, chloropicrin was discovered by James Stenhouse (*Phil. Mag.*, 1848, [3], xxxiii., 53) in 1848, and is highly poisonous; the Germans used it as a toxic material in gas warfare, being able to prepare it in quantity in the dye factories, and we, after the necessary delay for working out methods and installing plant, also used it in large quantities. The most powerful agent of all used in gas warfare, mustard gas, was discovered by Frederick Guthrie in 1860 (*Quart. Journ. Chem. Soc.*, 1860, xii., 116). The Germans were able to make it in their colour factories by an extremely complicated method and used it against us in June, 1917. It took us about a year to work out and instal a method of manufacture, much superior it is true, to the German procedure, with which to arm the necessary retaliatory measures. All the above substances were British discoveries, but at the outbreak of war we had no facilities for their large-scale manufacture, whilst the flourishing coal-tar colour industry of Germany was able to provide them in quantity. Now that serious endeavours are being made to place fine chemical manufacture on a proper basis in Great Britain, it should be the duty of all interested to insist that the great schools of experimental science in the country should be financed on such a scale as to enable them to train efficiently the vast amount of young inventive talent which the war has shown to exist among us; only by so doing will it be possible to secure the large numbers of highly trained young scientific men who will be needed, nor merely for the purpose of gaining the knowledge required for the manufacture of articles of commerce already supplied by Germany, but for producing new inventions which will carry us in front of German effort.

The record of Great Britain in chemical discovery is one of which she may well be proud, and many chemical industries now well established in Germany may be justly claimed as based entirely upon British discoveries. The coal-tar colour industry was initiated by the discoveries of Perkin, and was indeed established by him in this country before it was ultimately transferred almost wholly to Central Europe. Again, about a century and a half ago Henry Cavendish discovered that atmospheric nitrogen and oxygen can be caused to combine at the high temperature of the electric spark; this process, carried out on a minute scale in the laboratory by Cavendish, has been put into large scale operation in Central Europe and is used for the manufacture of huge quantities of nitric acid in Germany. Here again the development of a great scientific discovery made in this country has been left to Germany, and none of the practical fruits of the discovery have been gathered in Great Britain.

Our whole history during the war has consisted of a series of sequences in each of which some sudden military emergency has been met by rapid British scientific invention put into rapid practice by British technical effort; one of the major truths established by the war is that Great Britain commands a great galaxy of scientific, inventive, and executive talent. It is, of course, obvious that the lessons which have been brought home to us so forcibly during the war must be applied in peace if the history of the past five years is not to be repeated. The building up of all branches of chemical industry is essential, and, to the promotion of that end, a wide extension of the facilities for scientific education and research is necessary to this country. In one respect at least the British Empire is in a highly favoured position; in one part or other it produces every raw material needed for its manufactures, although in the past it has left these sources of supply to be exploited largely by the foreigner.

In the near future one great danger threatens us. We know that the large German colour works are again resuming their pacific manufacture of dyes and pharmaceutical products, and every sign is visible that German industrial chiefs are planning, by the intensive utilisation of their magnificent producing organisations, to become once more predominant in the world's markets, and thus to regain in peace what they have lost in war. One of the foremost German dye manufacturers, Professor Carl Duisberg, of Leverkusen, who helped his country valiantly in providing materials for gas warfare, has just expressed the conviction that he will be over in America again "very soon to see his old-time friends" (*Journ. Ind. Eng. Chem.*, 1919, xi., 509). A vast silent mobilisation of all the resources of German scientific industry is in course of realisation for the purpose of nullifying the legitimate consequences of military defeat.

It is instructive to note that Professor Hermann Grossmann, of the Technological Institute of the University of Berlin, who has been very active in denouncing the Allies for several years past, has just appeared in the technical press in a new capacity. He has recently published an open letter to chemists of the Allied and neutral countries on chemical falsehoods ("Ueber Chemische Legendenbildungen. ein offenes Wort an die Chemiker in die Ländern der Entente und an die Neutralen," *Chem. Zeit.*, July 24, 1919, xliii., 457). He bitterly deplores the fact that the activity and success of the Allies in propaganda were incomparably superior to those of Germany, and begs the whole world to send him literature bearing upon the chemical falsehoods which have been disseminated during the war, so that he may put the real case before chemists of all countries as quickly as possible. Dr. Grossmann refers sorrowfully to the scandalous misstatements made by the late Sir William Ramsay concerning chemical science in Germany; these statements seem now quite mild, and merely show that Ramsay exhibited rather more foresight than most men in the judgment of our late enemy. He is obviously pleased that *Nature*, "which during the war opened its columns to many quite absurd expressions of hatred for Germany, has recently recognised that, alter all, Germany has behaved throughout in a satisfactory manner during the war"; I have not myself observed anything in *Nature* which could lead Dr. Grossmann to these pleasing reflections. Lastly, the statement made by Lord Moulton in his eloquent Rede Lecture at Cambridge on June 5 last, that Germany did not venture to declare war until the synthetic manufac

ture of nitric acid had rendered the nation independent of over-sea importation of Chili saltpetre, is described as a chemical legend. It appears that we are on the eve of a powerful propagandist movement for the purpose of rehabilitating the German chemist in the eyes of the world.

ADDRESS TO THE BOTANICAL SECTION OF THE BRITISH ASSOCIATION.

BOURNEMOUTH, 1919.

By Sir DANIEL MORRIS, K.C.M.G., M.A., D.Sc., D.C.L., LL.D., F.L.S., President of the Section.

(Concluded from p. 175).

CONSIDERABLE progress has also been made with rice, the chief cereal food of the people of India. Of this eighty million acres are cultivated. A variety known as "Indrasail" is being rapidly propagated. The yields of this in 1915-16 were 30 per cent over the ordinary kinds. In 1918 two hundred tons of pure seed were distributed in Bengal, which contains one of the great rice-producing tracts of the world.

Some wheat breeding has been carried on in the Argentine by Backhouse, formerly attached to the John Innes Institution. The conditions in that great country extending from the Straits of Magellan to the tropic of Capricorn are exceptional in the diversity of soil and climate. The wheat cultivated in such widely scattered areas requires to be carefully adapted to local conditions, and the work must take a long time. Confining attention to the dry districts of the north, Backhouse found an interesting variety in general cultivation known as Barletta, which, though mixed and heterogeneous, was uniform in possessing a non-shelling character. Further, during periods of drought it acquired the habit of abandoning tillering and producing only one or two rows of ears. Its chief defect was its liability to be attacked by *Puccinia triticum* (not *P. glumarum*) In some years 20 per cent of the crop was lost owing to this rust. It was ascertained that European varieties immune to *P. glumarum* were susceptible to the Argentine rust.

A Chinese variety taken out by Backhouse was found to be immune to *P. triticum*. From this eventually was built up a form that combined some of the best qualities of the Barletta with the immunity of the Chinese. Backhouse has since endeavoured to increase the size of the grain, which is small in Barletta, and improve the general yield. The adaptability of the Barletta, as a non-sheller, to the conditions in the Argentine is due to the fact that the harvesting is done there by an Australian machine which cuts off the ears and threshes them at the same time. A non-shelling, or what is known as a tight-glumed, wheat is therefore essential.

As in wheat, so in cotton, this country is almost entirely dependent on foreign supplies. The uneasiness caused by the excessive dependence of the great Lancashire cotton industry, with exports of the annual value of over a hundred million sterling, on supplies from abroad, and the occasional shortage, have led to general action being taken to encourage the more extensive growth of cotton within the Empire. Next to the United States, which in some years have supplied seven-tenths of our imports, India comes second, but the East Indian cotton is not well suited to the requirements of the English spinner. Egypt, as the third producing country, supplies cotton of great strength and fineness.

The most valuable of all cottons is that known as "Sea Island" cotton owing to its introduction and successful cultivation on the coastal areas in South Carolina, Georgia, and Florida. With regard to this, it is interesting to learn that in recent years Sea Island cotton has been introduced back again to the West Indies, which was probably its original home.

This was effected by the Imperial Department of Agriculture in the West Indies in 1902, when a pure strain of seed raised from plants immune to wilt disease was obtained in quantity from James Island. This insured that the industry from the first was placed on a firm basis, and with the hearty co-operation of the planters an important West Indian cotton industry was successfully established. For some years the West Indian cotton has obtained a higher price than the corresponding grades of cotton from the Sea Islands themselves. The fine spinners in Lancashire are now practically independent for their supplies of this cotton from the United States. Further, it is not improbable owing to the serious attacks of the Mexican boll weevil on cotton plants in South Carolina and Georgia, the West Indies may become the only source of supply of fine Sea Island cotton. To enable the cotton industry to be established in the West Indies it was necessary from the first to ascertain the best type of cotton to grow in each island, how to plant and cultivate it, how to protect it from insect and fungus trouble, and how to maintain or improve the quality and quantity of the lint produced. The results so far obtained may be realised from the fact that the value of the exports of Sea Island cotton from the West Indies in recent years has reached a total of two million sterling. The general conditions in the West Indian islands owing to their small size and comparative isolation should enable them to maintain a high purity of cotton. In Egypt and other cotton-growing countries with continuous areas contamination by natural crossing leads to rapid deterioration of pure strains, so that a system of continued seed renewal is necessary. Harland, whose services in the West Indies have been provided by a grant from the Imperial Department of Scientific and Industrial Research, has in hand important investigations with the view of placing the work of cotton selection and breeding on scientific lines.

He has shown that the yield of lint per acre depends on a number of factors of a morphological and physiological character. In a general way it may be said that the yield is dependent on the climatic conditions, so an effort is being made to produce varieties which will interact with the environment conditions to the best advantage. Although Harland's work so far is of a preliminary character, he is able to suggest the conclusion that following certain lines of selection and breeding, and bearing in mind the relative importance of lint index and lint percentage, it is possible to isolate a strain of Sea Island cotton with a weight of lint per boll 31 per cent greater than that of the ordinary sorts in cultivation.

Considerable losses occur in some seasons from the attacks of insect and fungous pests. In some instances the internal boll disease is very destructive. This is due to the puncture of the young bolls by cotton stainers (Dysdercus) and green bug (Nezara), and the infection of the punctured locks or bolls by certain specific fungi which cause either total loss or the staining of the lint according to the amount of time of infection.

The green bug is naturally controlled by egg parasites, but the cotton stainers are subject to little or no control. In St. Vincent highly successful results have followed the systematic cutting out, over the whole island, of two species of trees (Sea-side Mahoe and the Silk cotton) on the fruits of which the cotton stainers breed during the period between the cotton crops. The investigation of the internal boll disease has entailed wide research, and illustrates the great complexity of problems in tropical plant pathology, as also the need of correlation and the combination of knowledge obtained by simultaneous action from several points of view.

A point of scientific interest is the inheritance of immunity in cotton from the attacks of the leaf-blister mite (*Eriophyes gossypii*). Harland believes he has obtained this by crossing an immune type of native cotton with a susceptible type of Southern Cross Upland cotton. In the F/3 generation all the plants breed true to immunity (*West Ind. Bull.*, xvii., 162). This is important from an

economic point of view, for it may lead to the possibility of the production of an immune strain of Sea Island cotton which has hitherto been very badly attacked by the leaf-blister mite. Another instance of immunity from insect attack is a hybrid of maize (*Zea indentata*) and *Teosinte mexicana*, which is claimed to be totally immune to the attacks of certain aphids (*Rev. App. Entom.*, Ser. A, vi., 29).

As already mentioned, India is the second largest producer of cotton. In 1906-7 it was estimated that there were about 20 million acres under cotton, with a production of nearly 5 million bales. It is unfortunate that the quality of East Indian cotton is not high in spite of the considerable efforts made in recent years to improve it.

Cambodia cotton for a time proved successful in Southern India, and has lately been introduced to Madras, but chief attention is directed to the improvement by systematic selection of pure strains adapted to local conditions. In Madras in 1917-18 there were 250,000 acres under new varieties of cotton, yielding increased returns to the rayats of the value of £416,000 per annum. A variety known as "roseum" was planted in the Central Provinces in 1916-17 on 700,000 acres, with the result that the profits to the growers reached a value of nearly one million sterling.

Leake's research work in the United Provinces, carried on for many years, is regarded as probably the most complete yet attempted with cotton in India. A variety known as K.22 has been widely distributed, and the produce in 1916 sold at 31 rupees per maund when local cotton was 25 rupees. Further, the ginning percentage has been raised from 33 to about 40, while the lint is of superior quality.

Leake has also been successful in raising an early flowering form of cotton on Mendelian lines. The new form differed from ordinary cotton cultivated in the United Provinces in that it assumed a sympodial instead of a monopodial habit. It not only yielded cotton of high quality, but it was found by its early flowering habit to suit the special conditions of the United Provinces.

As Egyptian cotton comes next to Sea Island cotton in quality it may be useful to refer to what has been done, or attempted to be done, on scientific lines to safeguard the industry. Its importance may be gathered from the fact that the area under cultivation is between a million and a-half and two million acres. Balls has fully reviewed the scientific and other problems that had to be solved in placing the industry on a satisfactory footing.

In the first place, as in all cotton areas, it had to be realised that it was necessary to produce varieties on pure lines. An attempt to produce crosses between American Upland and Egyptian cotton had to be abandoned. It was then resolved to select strains of individual Egyptian sorts and by the study of heredity on Mendelian lines to raise new varieties of pure strain. It was hoped by these means and by organising an effective system of seed distribution, year by year, to maintain the general purity of the crop. The chief difficulty met with was in respect of the relatively small size of the unit areas and the liability of the pure-strain plants being contaminated by pollen carried by wind or by bees from the neighbouring areas. According to Balls the high water-mark of Egyptian cotton growing was from 1895 to 1899. Since that time, although the actual area under cotton had been increased by 600,000 acres, the benefit measured in terms of cotton alone was small. It is probable that the attacks of the pink boll worm and other pests may have affected the results, but Balls and his colleagues came to the conclusion "that the falling off in yield was due to a rise in the level of the sub-soil water, or water table of the country brought about by the extension of the irrigation system during the past decade." The roots of the cotton plant were thus adversely affected at a critical period of growth. This recalls what Howard discovered, that one of the causes of the wilt disease in indigo India was the destruction of the fine roots and nodules during heavy monsoon rains. This shows, as suggested by Balls, how small was our real knowledge of the root functions of plants, and in the experiments carried on by him and his colleagues in Egypt they were "semi-consciously building up a general scientific knowledge of root-function worked out on the cotton plant as our material."

Balls, while carrying out numerous investigations bearing on the production of pure strains of Egyptian cotton, devised a method of recording crop-development by means of illustrative graphs likely to be adopted not only for cotton but other crops. Incidentally, he proved that the close-planting method on ridges adopted by the native cultivators in Egypt was more advantageous than the wider planting adopted in the United States and other countries. It is a sign of the times that a British Cotton Industry Research Association has recently been formed at Manchester to promote a wide scheme of research in connection with the production of cotton and its utilisation in industry. It will employ a staff of scientific and skilled workers, and maintain scholarships, and eventually a Cotton Research Institute is in contemplation. It also proposes to establish research stations in the cotton-growing portions of the Empire for the investigation of the growth of cotton and the careful and complete study of the scientific problems that may arise.

Probably the most remarkable instance on record of the successful combination of science and enterprise in the tropics is the establishment of a cacao-growing industry in the colony of the Gold Coast, West Africa. Thirty years ago no cacao of any kind was produced on the Coast. Owing, however, to the foresight of the then Governor (Sir William Brandford Griffith), who sought the powerful aid of Kew, cacao growing was started in a small way among the negro peasantry, with eventually extraordinary results. After selecting the locality for the experiments, seeds and plants were obtained through Kew, and a trained man was placed in charge (*Kew Bull.*, 1891, 169; 1895, 11). The first exports in 1891 amounted to a value of £4 only. So rapid was the development of the industry that ten years later the exports reached a value of £43,000. By this time both the people and the Government had begun to realise the possibilities of the situation, and systematic steps were taken to organise under scientific control a staff of travelling agricultural instructors to advise and assist the cultivators in dealing with fungoid and insect pests and improve the quality of the produce. In 1911 the exports had increased nearly fourfold, and reached a total value of £1,613,000, while in 1916, what may possibly be regarded as the maximum exports, were of the value of £3,847,720.

It should be borne in mind that this Gold Coast cacao industry, now one of the largest in the world, has been called into being and developed entirely by the agency of unskilled negro labour, and on small plots from one to five or ten acres in extent. The controlling factors were, first, the selection of suitable land for cacao growing; next, the selection and supply of seeds and plants of varieties adapted to local conditions; and, lastly, the advice and tactful assistance of trained Europeans backed by the resources of science.

Coming nearer home, Henry, well known from his association with Elwes in the production of "The Trees of Great Britain and Ireland," by historical research and experiment has established the fact that many fast-growing trees in cultivation, as the Lucombe Oak, Common Lime, Cricket-bat Willow, Black Italian Poplar, Huntington Elm, &c., are hybrids. It was of high scientific importance to discover the origin of these valuable trees. Further, by artificial pollination Henry has succeeded in raising new hybrids which display the extraordinary vigour characteristic of the first-generation cross. Perhaps the most notable, so far, is a new hybrid Poplar (*Populus generosa*), which makes the strongest shoots of all Poplars.

The astonishing vigour of hybrid trees is well illustrated in the case of the Cricket-bat Willow, a natural cross between *Salix fragilis* and *S. alba*. "This often attains in fourteen or fifteen years, from the planting of sets, fifty to sixty feet in height, with three and a-half to four feet in girth—a size suitable for cleaving into bats." It is claimed in the case of many hybrid trees "it is possible to produce much greater bulk of timber in a given time." The common belief that quickly-grown timbers are of inferior quality is said not to hold good in respect of any quality in Ash, Oak, and Walnut. In fact, according to Dawson, "with oak, ash, and walnut the quicker their growth the better their quality in every way. They are more durable, more elastic, and less difficult to work" ("Science and the Nation," 138). It is further claimed that by hybridising it may be possible to produce disease-resisting varieties and varieties carrying with them other desirable characteristics.

Difficulties are met with in hybridising trees in this country owing to the variable climate and the absence of pollen and desirable sorts. To obviate these and provide adequately for the work it should be undertaken on organised lines, as in wheat breeding.

Henry has recently made an elaborate investigation into the history of the London Plane (*Platanus acerifolia*) (*Proc. Roy. Irish Acad.*, xxxv., B.2:10). He has established the fact that this tree, never seen anywhere in the wild state, is intermediate in character between an American and a European species. He claims it has all the peculiarities of a first cross. As usual in hybrids of the first generation, its seeds when sown produce a mixed and varied crop of seedlings, in which are variously combined the characters of the two parents.

Henry's researches show that the London plane probably orginated in the Oxford Botanic Garden about the year 1670, when both the occidental and oriental planes were established there. The finest and probably the oldest London plane in Europe is growing in the Palace Garden at Ely. It was planted by Bishop Gunning between 1674 and 1684. The vigour of the London plane is remarkable. It is extensively used for planting in London and other towns in this country, and also in Europe and North America, "as it has been found to surpass all other trees in its powers of resistance to drought, smoke, and other unfavourable conditions of soil and atmosphere."

In the Tropics breeding experiments in the case of india-rubber trees are likely to prove of great value. In the meantime, selection of seed from the best trees is being carefully carried out in the hope of increasing the general yield of the plantations. In Java the proportion of alkaloids in the bark of introduced Cinchona trees (yielding quinine) have nearly doubled by careful selection on these lines. In the case of rubber trees, which are known to possess marked individuality in regard to the amount of latex which can be drawn from them, it is suggested that seed for planting should be taken only from trees selected for their high-yielding capacity. In fact, the selection of seed bearers may play an important part in the future development and permanence of the rubber industry. Where good seed is not readily available Lock has suggested that the best trees might be raised from cuttings.

Plant-breeding experiments with india-rubber trees have already been attempted, but they are not likely to be of much value if they are confined to empirical and haphazard lines. It is suggested that they should be carried on at well-staffed and well-equipped stations devoted to breeding and kindred problems. Such stations should be established in each of the main rubber-growing regions. Work of this kind must be lengthy and complex, but it is absolutely essential to ensure the safety of an industry which is estimated to be of the annual value in the Middle East of about fifty millions sterling. The Agricultural Department in Ceylon, which is fully alive to the fundamental importance of selection and breeding india-rubber trees, has already taken some action in the matter. For instance, at the Heneratgoda Gardens there are fifty *Hevea* trees whose individual latex-yield has been recorded for every tapping since June, 1908. One tree marked No. 2 has yielded an amount of rubber far in excess of any other tree. In 1912 seeds and stumps taken from this tree have been established on a plot of three acres at the Experimental Station at Peradeniya. When the trees are fit for tapping and the good yielders are determinded the others will be cut out and the remainder reserved for seed purposes.

Another investigation in hand is to determine whether the latex-yielding quality of *Hevea* trees can be associated with any definite botanical characters and to what extent such characters are transmittable. Twenty trees of the same age growing in a four-acre block have been selected for differences in leaf and bark characters. These are all tapped on the same system, and the yield of rubber from each tree is recorded separately for each tapping (*Kew Bull.*, 1917, 118).

The value of these and other experiments of a like nature may be realised when, according to Varnet, quoted by Johnson, the yield of rubber from different trees of *Hevea* growing under similar conditions in the same plantation may vary as regards volume of latex from 4 to 48, and in percentage of weight of dry rubber from 1·286 to 14·164 (*Journ. d'Agric. Tropicale*, 1907).

Bateman a few years ago expressed the opinion that nowhere is the need for wide views of our problems more evident than in the study of plant diseases. Hitherto, he said, "this side of agriculture and horticulture, though full of possibilities, for the introduction of scientific methods, has been examined only in the crudest and most empirical fashion" (Address, Section M., 1911). Since then some advance has been made in the morbid physiology of plants, but such work to be carried to a successful and practical issue demands careful experiments carried on continuously by specialists for many years.

Keeble suggests that "the professional mycologist is accustomed to confine his attention too exclusively to the active agent of the disease," while, on the other hand, "the professional cultivator gives habitually great weight to the possibility of preserving plants from disease by improving his methods of cultivation. Both are right, yet neither is wholly wise, and there is much room for a race of mycologists who not only discover how to cure plants but know how to cultivate them ("Science and the Nation," 118). As we have already seen, Biffen and others have shown that under certain conditions the quality inherent in some varieties to resist disease may be utilised to great advantage. The national importance of such work is impressed upon us by the enormous losses sustained every year by rust in wheat, mould in hops, and the widespread disease of potatoes. One of the most striking instances in recent times was the destruction of the valuable coffee plantations in Ceylon. The industry, an exceptionally valuable one, was wiped out in a comparatively few years by the coffee-leaf disease (*Hemileia vastatrix*). In the light of our present knowledge it is not improbable that this disease may have been checked by seed selection or raising an immune race of plants. Or, more probably, as suggested by Armstrong, by regulating the use of essentially nitrogenous manures, which are known in some cases to intensify the attacks of fungoid pests and substituting the use of phosphates.

In the Malay States the life history of some of the more prominent diseases of rubber trees has received close attention. *Fomes lignosus*, a root fungus, is local in character, and as its effects quickly appear there is time to take remedial measures before the neighbouring trees are affected. *Ustulina zonata*, causing collar-rot, on the other hand, is slow in action, and therefore all the more dangerous. A third rubber disease, *Fomes pseudo-ferreus*, spreads entirely by the contact of the roots with diseased jungle stumps, or roots of other diseased rubber trees. As remedial measures are impossible in this instance a clean-clearing policy is being vigorously advocated, and under scientific advice this may become the rule on all

young rubber estates in the East. In this country Salmon, who is undertaking a detailed study of the hop mildew (*Sphærotheca humili*), has obtained seedlings which he states "have retained immunity after four years' trial in a hop garden under normal conditions of cultivation and manuring." As the depredation of mildew, commonly known as mould, causes great loss to hop growers, the research work carried on by Salmon is watched with great interest. Progress is necessarily slow, but a hop immune to mould would be a valuable acquisition in hop-growing districts. In the successful treatment of the diseases of plants the field of work in the Empire is realised as practically without limit; but it is one in which advance must be made by the development of pure science, and by men with a broad outlook and fully in touch with the practical as well as the scientific side.

As illustrating the occurrence of an incidental result arising from a purely scientific investigation, mention may be made of the discovery of a remarkably tall strain of flax at the John Innes Institution. This, if capable of being established on pure lines, may prove of economic value. It is a hopeful sign that the appreciation of the work done at this institution, under the stimulating energy of Bateson, is increasing day by day. The broad-minded interpretation that has been placed on the generous bequest made by Mr. Innes, and the recognition of the fact that an accurate knowledge of heredity must form the basis of the bulk of the new work in horticultural breeding, are full of promise. We have, further, the assurance that recognition will be given to the principle that if progress is to be made theory and practice must be closely interwoven. Amongst other important investigations undertaken at the John Innes Institution, Miss Ida Sutton has recently published a Report on Self-sterility in such fruit-trees as plums, cherries, and apples. It has been recognised that failure in fruit crops is not infrequently due to self-sterility. Two main questions were dealt with—(1) whether self-sterility is a simple Mendelian recessive character, and (2) whether self-steriles are fertile with the pollen of any other variety. So far, with regard to (1), the results show there is nothing which negatives the view that the property of self-sterility may be recessive, and in regard to (2) what East has called "cross-incompatibility" is not confirmed by Miss Sutton's researches. The general conclusions arrived at by Miss Sutton are—(*a*) that many important commercial varieties of fruit trees set little or nothing unless cross-pollinated; (*b*) that for the pollination of these self-sterile kinds pollinisers must be planted; (*c*) that provided a variety produces plenty of pollen and flowers simultaneously with the variety which is intended to pollinate, any variety, at least of plums and apples, will probably serve for this purpose, apart from the special case of the Coe varieties of plums and their presumable co-derivative, Jefferson. We may mention the great success which is attending the establishment of a school of technical education and research by the Royal Horticultural Society at Wisley. This is maintained by liberal funds, and by means of its well equipped laboratories and extensive trial grounds it offers unique facilities for solving problems of great value as affecting the future of British horticulture. In sympathy with the work at Wisley private firms are also setting up laboratories of their own and employing men of high standing, so that a just balance will be maintained between science and practice. By such means research will be stimulated and encouragement given to individual initiative which is recognised as fundamentally important in the advancement of science.

In schemes of intensive cultivation so ably advocated in reference to food production, it is well to bear in mind that it may be possible in some instances to go beyond what is necessary to achieve the object in view. Russel is of opinion that "the more intensive the cropping the greater the opportunity for the various pests to live. . . . Further, most pests have their parasites, and wholesale sterilisation may help the pest by destroying the parasites. Imms has recently noted two cases where this is said to have happened" (Address, 1916, p. 17). I may add a third instance of this character in the case of the Moth Borer attacking sugar-canes in the West Indies. For probably something like two hundred years the moth borer had been regarded as the most destructive enemy of the sugar-cane. Its life history was unknown until Lefroy, then attached to the Imperial Department of Agriculture, discovered the eggs which were deposited in a greenish cluster on the back of the leaves of the sugar-cane. The egg clusters were so inconspicuous that they had entirely escaped notice. The first steps were to employ boys to cut off portions of the leaves with the eggs and burn them. It was afterwards discovered that many of the eggs were parasitised, and the planters were thus unknowingly destroying the parasite, and practically increasing rather than diminishing the attack of the moth borer. On the further advice of Lefroy the leaves with the egg clusters were not burned but spread out in the shade to enable the parasites to hatch out, with the result that in the later stages of the crop nearly all the moth-borer eggs were parasitised, and the loss in canes in that and the succeeding crop was largely reduced by natural means.

The progress made in the elucidation of problems in tropical plant pathology shows not only the necessity for well trained and experienced mycologists and entomologists, but also for the correlation and combination of knowledge gained in their several lines of study. It is suggested that research work should be organised on the broadest possible lines, and combine the biological services of the whole Empire. We have a first step in this direction in the Imperial Bureau of Entomology, with its headquarters at the British Museum. Those acquainted with the efficient work done by this Bureau and the excellent publications issued by it will very heartily welcome the establishment of the proposed Imperial Bureau of Mycology, to carry on its work on similar lines.

In this brief review I have endeavoured, however imperfectly, to place on record some of the activities that have taken place in the domain of Botany in recent years. It has only been possible to select a few of the most striking incidents where progress has been made. This has been done in the hope of arousing wider interest in work of prime importance as affecting the interests of the home country and the Empire. Botany in its widest aspects affects so largely the welfare of the human race it is impossible to slacken our efforts. Advance has necessarily been slow, but the creative impulse of science cannot fail to bring in a large harvest of results. This may be possible by encouraging individual efforts, by organising active co operation, and in associating with us men who are practically grappling with difficulties that seem almost impossible to solve. I have attempted to show in what vast fields of enterprise botanical science has already rendered signal service. As regards the future, if we enlist the best intellects imbued with the true spirit of progressive research, we shall ensure a continuance of discoveries that have proved so effectual. We must also call to our assistance some of that wonderful energy developed during the war and divert it to the great work before us.

Certainly one of the outstanding features that emerges from a record of botanical research during the last decade or two is the prominent position occupied by plant-breeding on Mendelian lines. In proof of this we have the numerous well-equipped plant-breeding institutes established and maintained by Government and private funds. Plant-breeding is now in the forefront in relation to the improvement of crops, and the value of it is officially acknowledged as "a vital element in the national policy." According to the Secretary of the Board of Agriculture, what we want "are new races of plants adapted to intensive cultivation," and, he adds, "it is my deliberate opinion that an increase in the production of our land is much more easily attainable in that direction than in any other."

THE OIL IN PEA-NUTS.

By NELDA SCHLUE and HAROLD L. MAXWELL.

DURING the last few years, in which there has been an urgent need of fats to be used for food and glycerin for explosives, the subject of vegetable oils has received more than ordinary attention. Corn, oats, wheat, peach seeds, cherry seeds, prunes, olives, and the various nut kernels have each been carefully investigated as to their oil content, and the character and chemical properties of each oil accurately determined. It is thought that to repeat a similar study with the oil contained in pea-nuts might not be without interest.

We procured a quantity of the fresh unroasted pea-nuts and removed the shell and adhering husk. The bare kernels were cut on a watch-glass with the aid of a knife. Twenty grms. of the chopped kernels were transferred in a "fat-free" sack to a Soxhlet apparatus, and extracted with boiling ether for twenty-five and a-half hours, when it was found that all the oil had been extracted. The ether-oil mixture was transferred to a distillation flask, where the constituents were separated by fractional distillation. The oil as obtained was clear and slightly yellow in colour, and made up more than 50 per cent. of the weight of the original kernels.

The first experimental work on the pea-nut oil was to determine the iodine number. This we did by the Hanus method, and found the iodine number to be 94·5 and 95 respectively in two samples.

Another necessary procedure in the analysis of a specimen of oil is to determine its saponification equivalent. By the saponification equivalent we mean the relative amount of saponifiable oils in a given fat, expressed in terms of mgrms. of potassium hydroxide, that were used to saponify the oil. We proceeded with the saponification of the pea-nut oil, using the Koettstorfer method. The results obtained were 197, 200, and 202 respectively. This value is about 2 per cent higher than the equivalent found by former workers.

The chemical composition and conduct of pea-nut oil (more often called arachis oil) is very similar to olive oil, and this fact has led a few dealers to adulterate the pure olive oil with this cheaper oil. The similarity of these two oils makes it difficult to determine accurately the percentage of each in a mixture. In a book, "Edible Oils and Fats," C. Ainsworth Mitchell makes a comparison of the typical values of the arachis and the olive oils as follows:—

	Sp. gr.	Saponification No.	Reichert-Meissl.	Hehner value.	Iodine value.
Arachis	0·917	185·5	0·48	95·5	92
	0·9256	196	—	—	100·8
Olive	0·916	185	—	94·0	79·0
	0·919	196	—	96·0	93·0

The most reliable method of differentiating between the pure oils and a mixture of the two is to make a quantitative determination of the mixed arachidic and lignoceric acids. The method to be used involves the separation of the two lead salts by means of ether. These acids are recovered by crystallisation from hot alcohol.

The well-known fact that glycerides of the oleic acid series may be converted into isomeric compounds by nitrous acid gives us the basis for the elaidin test, which we use in further investigation of the oil sample. Two cm. of the oil were mixed with an equal volume of concentrated nitric acid and a pale rose colour was noticed after one minute. When heated on the water-bath for five minutes the mixture became yellowish brown. After cooling and standing at room temperature for twenty-four hours the mixture was solid. It has been found that other oils, like arachis oil, containing a large percentage of oleic acid, form similar isomers when given the acid treatment.

Cornell College, Mount Vernon, Iowa
September 17, 1919.

DISTILLATION OF AQUEOUS SOLUTIONS OF RELATED ORGANIC SUBSTANCES.

By JOSEPH REILLY, M.A., D Sc.,
and
WILFRED J. HICKINBOTTOM.

WHEN dilute solutions of organic fatty acids are distilled it is well known that certain regularities are observed (compare Duclaux, *Ann. Inst. Pasteur*, 1895, ix., 265, 575; Naumann and Müller, *Ber.*, 1901, xxxiv., 224; Stein, *Journ. Prakt. Chem.*, 1913, lxxxviii., 83). Various forms of distillation constants have been advanced by these authors to express such regularities. These constants may be derived from Nernst's law of distribution. This law may be used as a starting-point for the discussion of the theory of distillation of dilute solutions (Reilly and Hickinbottom, *Sci. Proc. Roy. Dub. Soc.*, 1919, xv., 513). For large changes in concentration Nernst's law does not hold exactly, and a method of steam distillation is recommended in which only small changes in concentration occur. By plotting the constants for the normal fatty acids (formic to caprylic acid) against the number of carbon atoms present in the acid, an approximately straight line results, showing an interdependence between molecular constitution and rate of steam distillation. Acids containing a branched carbon chain (as isovaleric) have greater constants than normal acids of the same molecular weight. The experimental evidence at present available shows that for isomeric substances (as, for example, *normal* and *iso* butyric acids), the distillation constants are distinct enough to differentiate between the substances.

The lower saturated monohydric alcohols, phenols, and other substances have been distilled in a current of steam under definite conditions, and results have been obtained showing a relation between molecular complexity and the distillation constants.

In cases where the constitution of a substance is uncertain, and when it is volatile in steam, a comparison of its distillation constants with those of allied substances may assist in deciding its molecular constitution.

Within certain limits the distillation constants for formic and acetic acids and the lower saturated aliphatic alcohols are subject to variations depending on the concentration. The addition of certain non-volatile substances, such as acids or salts, also causes an alteration in the distillation constants. As the homologous series of saturated fatty acids and alcohols are ascended, the distillation constants increase with the molecular weights, the reverse of what might be expected from a knowledge of the vapour tension of the pure substances. It is considered likely that the tendency for the acids or alcohols to form molecular complexes may account for this behaviour.

As well as using the method of steam distillation for analysis of fermentation products, and various technical preparationss containing the volatile fatty acids, a method has been worked out to detect the presence of butter and of fats of the cocoanut-oil type in margarine and other products. By determining the distillation constants of the water-soluble volatile acids under definite conditions, constants for the fats are obtained which differ considerably in the case of butter fats compared with other fats which have been examined (cocoanut-oil, palm-kernel oil, babassu fat).

GERMAN GOODS AT THE LEIPZIG FAIR.—There is an evident desire on the part of the German nation to recover itself; but the dependency of Germany upon foreign raw material and increased coal output is very evident. German glass, pottery, textile, leather, and other industries are in many cases closed down or are operating at from 5 per cent or 10 per cent of their normal output, on account of the inability to purchase raw material at the present value of the mark.

* Read before the British Association (Section B), Bournemouth Meeting, 1919.

NOTICES OF BOOKS.

Practical Sanitation; A Handbook for Sanitary Inspectors and Others Interested in Sanitation. By George Reid, O.B.E., M.D., D.P.H. With Appendix on Sanitary Law. Illustrated with Diagrams. Nineteenth Edition, Revised. London: Charles Griffin and Co. Price 7s. 6d. net.

The fact that this book has reached its nineteenth edition since it was published in 1892 shows that it has been appreciated.

Written originally with the object of enabling sanitary inspectors to acquire "a practical and scientific knowledge of their duties," the work has become a standard of reference in all matters connected with sanitation.

For the present edition the text has been revised and brought up to date, and the valuable Appendix on Sanitary Law has been amended as far as possible, but the author in his preface regrets that the long expected codification of the many Acts of Parliament which govern procedure has not yet been effected.

The practical value of attention to sanitary matters is well illustrated in the table, showing the improvement in the death rate, from 1862, when it stood at 22·6 per thousand, until 1915, when it had fallen gradually to 14·3 per thousand.

Although formerly intended for sanitary inspectors and others professionally interested in the subject, the book can be read with interest by the general reader and with advantage by those who will be responsible for the long-desired house-building operations.

A distinct feature of the book is the very numerous diagrammatic illustrations; these can be easily followed by the workman, which with the lucid explanations of the principles involved, invest it with a thoroughly practical character.

NOTES.

Note from the Astronomical Observatory of Harvard College.—The New Star in the constellation Aquila was first seen on June 8, 1918. The Observatory at once sent out cablegrams and letters, requesting observations of the brightness of the New Star, not only to Europe and America, but also to our correspondents in Africa, Japan, Australia, New Zealand, and the Sandwich Islands. As a result, including a few published observations, we have received 2094 estimates from 90 observers. Measures have been obtained on every night since its first appearance, and on many days when it was below the horizon in America. Thus, for the first time, a nearly continuous watch has been kept of a celestial object by a chain of observers extending around the earth. Photographs taken here show its existence before its discovery, from May 22, 1888, to June 3, 1918. During this time it underwent slight variations in light. Three photographs on June 7, 1918, showed it of the sixth magnitude, about one hundred times its original brightness, and during the next day it again increased about two hundred times.

The Secretary of the Department of Scientific and Industrial Research informs us that a British Association of Research for Cocoa, Chocolate, Sugar, Confectionery, and Jam Trades has been formed in accordance with the Government scheme for the Encouragement of Industrial Research. The Secretary is Mr. R. M. Leonard, the Manufacturing Confectioners' Alliance, Ltd., 9, Queen Street Place, E.C. 4.

Exhibitions of British Goods at Sao Paulo.—In order to ensure the success of the series of exhibitions which is being held at Sao Paulo by the British Chamber of Commerce of Sao Paulo and Southern Brazil, it has been resolved that British merchants and exporters, as well as manufacturers of British goods, shall be invited to participate. The first of the series of exhibitions (textiles), has had to be postponed for a few months, but it is hoped that the second, covering hardware and trades allied to that industry, may be inaugurated not later than January 1, 1920, to be followed by an exhibition of fancy goods on or about April 1, 1920. The object of the Chamber in arranging for this series of exhibitions is solely that of encouraging the sale of British-made goods in the Brazilian market, and it is hoped that British merchants and exporters will take advantage of this opportunity to bring their goods to the notice of local buyers.

Austrian Enterprise in the Far East.—An Austrian pamphlet, written in English, and advertising a grinding machine, was recently received by a British consulting engineer in Bangkok from a well-known Austrian firm. It is of interest as showing that no time is being lost by enemy firms in their attempt to enter the world's markets once more. Pre-war trade in this class of machinery with the Siamese market was done for the most part with Germany and Austria, and strenuous efforts will no doubt be made by firms in the latter countries to regain the market. If British firms wish to maintain any trade which they may have captured in the Siamese market during the war, particularly in the above type of machinery, they will need therefore to be especially enterprising and watchful. A copy of the pamphlet describing the machine may be seen at the Enquiry Room of the Department of Overseas Trade, 73, Basinghall Street, E.C. 2.

Institution of Petroleum Technologists.—At the meeting on Tuesday, October 21, at the House of the Royal Society of Arts, at 5.30 p.m., a paper will be read by Mr. Arnold Philip, B.Sc., &c., on "Some Laboratory Tests on Mineral Oils."

UNIVERSITY OF ABERDEEN.

DEPARTMENT OF CHEMISTRY.

Two RESEARCHER-ASSISTANTS are about to be appointed in this Department. Persons who desire to have their names considered should send them, along with testimonials, to the Secretary of the University, before October 27. The salary is £250 per annum.

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THE CHEMICAL NEWS

VOL. CXIX., No. 3106.

ANALYTICAL STANDARDISATION.

By N. D. RIDSDALE.

Now that reliable standard analysed samples of steel and iron are available and being extensively used in the United Kingdom, and that the application of standardisation to analytical chemistry is being more widely contemplated, it seems desirable to examine the principle more closely and to determine exactly how it should be utilised in order to be of lasting benefit.

A standard may be defined as "that which is established by authority, custom, or general consent as a model or example — criterion" (Webster), so that a standard analysed sample really means one which, by authority or common consent, has a recognised value or composition; whereas a standard method is one which for similar reasons is set up as a model on account of its accuracy and simplicity.

It must be remembered, however, that the real authoritativeness of a standard of any kind is dependent entirely on its correctness or approach to perfection and not necessarily on the extent of the approval or adoption which it at first receives.

The immediate object of standardisation, in general then, ought to be to lift the less capable up to the highest possible efficiency; hence it is imperative that only those best fitted for promoting it should be chosen for the task, and that their suitability should be gauged, not merely by their technical skill, but also, none the less, according to their disinterestedness and genuine desire to form the character of those for whose use the standards are intended.

There seems little doubt that for chemistry a small staff of experienced analysts, free from any other professional ties and elected by ballot, is what is needed. Their selection would be of first importance; for if they were not men of great ability, standard samples might be prepared which lacked either homogeneity or accurate analytical evaluation, and standard methods might be recommended which were in some degree obsolete; thus, instead of elevating those using them they might have the opposite effect.

Nobody gets far with the analytical standardisation of samples before discovering some defects in the methods employed, and each one ought to realise the desirability of making known—for the benefit of the majority—what has been his experience as to the best methods for testing a given material. Fortunately there are few now who still think there is anything to be gained by keeping their methods to themselves. Yet many who approve of the use of standard analysed samples deprecate the use of standard methods. This aversion is probably nearly always due to uncertainty as to the way the standardisation of methods would be carried out and the effect it would produce. Any progressive minded chemist finding himself required to use an inferior method of analysis appointed by a body unfitted for the authority it was intended to wield would naturally object; but who would not welcome the findings of any able body which, for example, had tested the innumerable methods proposed for the analysis of "white metal" alloys, and having determined the best one—or perhaps two—*recommended* them, though did not enforce them, for adoption. Standardisation of methods on the latter plan, where enforcement is not resorted to, would be an immense help, for instance, to students or busy chemists who might wish to find out quickly the best methods for the analysis of some substance with which they had had little experience. If an individual author of a text-book of reliable analytical methods is appreciated for making known his experience, how much more should a body of the most able chemists be esteemed if it published its combined experiences!

It is sometimes asserted that the use of modern simplified methods results in the chemist gaining less knowledge of chemistry than was required formerly to test a given material, and that therefore the opportunity for developing the chemists' mental capacities is diminished. This conclusion, however, is misleading. For instance, what did happen during the war as a result of standardisation—in whatever direction it was applied—was that men and women of less training were enabled to undertake work which formerly required more skill, and consequently those who had greater ability were relieved of their former duties and enabled to devote themselves to more difficult and urgent problems. The result was a great unfolding of ideas and unprecedented progress in science.

Standardisation could only be derogatory if those affected by the simplification and saving in time it brought them failed to utilise the opportunity thereby afforded to devote themselves to accomplishing something which would be of greater value than what they were doing formerly. Even if they did mis-apply the principle, however, it would not be a valid argument against standardisation, but would simply indicate the importance of the initiators of the movement warning those wishing to partake of its fruits, that unless they were animated by the desire to use it only for progressive ends and not simply to enable them to become less active, they would inevitably lose and not gain by the change.

These principles are, of course, not new but only old ones revived in order that the object once having been understood should be kept well to the fore, and not, as is so often the case, perverted and lost sight of in the execution of the multifarious technical details.

Even in the last few years, during which standardisation has been increasingly applied, it has resulted in much time having been saved, many hidden sources or error detected and overcome, and a higher degree of accuracy maintained.

ON A MODIFICATION OF THE REDDROP AND RAMAGE METHOD FOR THE DETERMINATION OF MANGANESE IN STEEL.

By P. L. ROBINSON, M.Sc. (Dun.), A.I.C.

I. *Reddrop and Ramage Method.*

1. *Solution.*—1·1 grms. of steel are weighed into a conical beaker, 30—40 cc. of nitric acid (sp. gr. 1·2) are added, and the assay heated to boiling on the hot plate. Boiling is continued until the red nitrous fumes cease to be evolved, when it is removed from the plate and allowed to cool.

2. *Preliminary Oxidisatioa of Carbonaceous Matter and Reduction.*—1—1·5 grms. of sodium bismuthate are added, and the contents of the beaker are raised to boiling. Boiling is continued until a brown precipitate of hydrated manganese dioxide forms. (If this precipitate is not obtained the assay is allowed to cool, more sodium bismuthate is added, and it is again boiled). The precipitate is removed by the addition of a few drops of sulphurous acid while on the plate. Further boiling is allowed to remove all traces of the reducing agent.

3. *Final Oxidisation and Titration.*—The assay is allowed to become quite cold, 1—1·5 grms. of sodium bismuthate are added, and the manganese is completely oxidised to the permanganic state. Excess of bismuthate is removed by filtration through asbestos by means of a pump, and the filtrate is titrated with N/10 ferrous ammonium sulphate and N/10 potassium permanganate.

II. *Modification.*

The modification of the above method is made in the "preliminary oxidation of carbonaceous matter and reduction."

The assay is not removed from the plate after "solution," but immediately the brown fumes have cleared 5 cc. of ammonium persulphate (120 grms. to 1 litre of water) are added. This immediately oxidises the carbonaceous matter. Five to ten minutes boiling is allowed to decompose the excess of persulphate.

"Final oxidisation and titration" (see above) are now proceeded with.

III. *Theoretical Considerations.*

The oxidisation of the carbonaceous matter is obtained by the direct action of the persulphate, which, on addition, immediately evolves atomic oxygen. Using this strength of solution no manganese is oxidised to the permanganic state, and therefore no hydrated manganese dioxide is precipitated. Thus there is no need for reduction, but care must be taken to boil sufficiently to decompose the excess of persulphate.

(Note.—In the case of steels containing chromium, reduction is naturally necessary together with the usual rapidity of final oxidisation and titration).

The quantity of ammonium persulphate added is sufficient to oxidise the carbon in commercial steels (*i.e.*, 0 up to 1·5 per cent). It may be increased in the case of high carbon content.

A number of determinations show that the modified method gives a result identical with the original method in the case of both steel and ferro-manganese.

IV. *Advantages.*

1. The "preliminary oxidisation of carbonaceous matter and reduction" are reduced to one operation.
2. Time is saved as no cooling is required.
3. The use of the unpleasant reagent sulphurous acid is avoided.
4. Filtration is assisted by the reduction of the amount of bismuth and sodium nitrate in solution.
5. The quantity of sodium bismuthate (a very expensive reagent) used is reduced by one-half.

60, Earl's Dene, Low Fell, Gateshead.

EARLY TYPES OF BRITISH RESPIRATORS.

By T. JOHNSTON.

In the early days of gas warfare, when pure chlorine was the only gas used for offensive purposes, the preliminary types of gas masks were quite efficient, and proved to be satisfactory enough. The concentration of gas was so low that a very simple mixture of chemicals was found to be successful in counteracting the effects of the gas in the field.

With the introduction of phosgene, and the possible appearance of metallic poisons, lacbrymators, and vesicants, however, the early types had soon to be discarded. With the rapid development of chemical warfare there was a simultaneous development of protective appliances and principles, culminating in the introduction of the box respirator and the elaborate scheme of anti-gas training until recently in operation. Even the box respirator—a striking example of ingenuity and convenience—has been modified from time to time, but never has it proved any thing but a thoroughly satisfactory protection against all poisons and lung irritants that have been employed by either group of belligerents.

The first respirator ever supplied to the British troops was very crude—a rough pad of cotton waste covered with black gauze, and impregnated with a solution of "hypo." When used it was just tied over the mouth and nostrils, preventing speech and causing vomiting. All that can be said for it is that it absorbed chlorine, and sufficed until a better and more comfortable pattern of respirator could be provided.

The "helmet" respirator was the next device. It was merely a flannel bag fitted with a strip of mica for visionary purposes, and treated with a solution of sodium carbonate and "hypo." It was worn over the head and neck, and was tucked in under the collar of the tunic. Although much more comfortable than the first type it became extremely hot after a short time, and owing to the formation of small quantities of sodium hypochlorite the troops had the idea that the helmet was allowing the gas to come through. The following are the reactions that take place:—

1. $Na_2CO_3+H_2O = 2NaOH+CO_2$.
2. $2NaOH+Cl_2 = NaCl+NaOCl+H_2O$.
3. $2Na_2S_2O_3+Cl_2 = Na_2S_4O_6+2NaCl$.

Sodium Tetrathionate.

As far as chlorine is concerned the helmet was quite a good mask, and was quite satisfactory in practice, but the employment of other gases had to be kept in view. For example, the forward reaction with prussic acid probably would not proceed sufficiently to ensure adequate protection:—

$$Na_2CO_3+2HCN = 2NaCN+CO_2+H_2O.$$

The need for improvement was evident, and the dipping solution was replaced by a mixture of caustic soda, phenol, and glycerin in water. In this mixture a free alkali would always be available to neutralise any acid that is formed in the reaction between phenol and chlorine:—

$$C_6H_5OH+3Cl_2 = C_6H_2Cl_3OH+3HCl.$$

The introduction of phenol considerably reduced the action of the caustic on the skin by the formation of sodium phenate:—

$$C_6H_5+NaOH = C_6H_5ONa+H_2O.$$

This reaction, however, in no way interferes with the chemical function of the soda, for the presence of the acid hastens the back reaction. The glycerin acts somewhat similarly, and, being somewhat hygroscopic, tends to keep the helmet moist, and thus assists the reactions. Obviously the excess of free alkali is important, and an excess of 5 per cent over the amount of soda required by the phenol, if the forward reaction were completed, is used.

The action of phosgene is very similar, forming phenylcarbonate and hydrochloric acid, which is neutralised by the soda.

1. $4NaOH+COCl_2 = Na_2CO_3+2NaCl+2H_2O$.
2. $C_6H_5OH+COCl_2 = (C_6H_5)CO_3+2HCl$.

It was found that the foregoing reactions did not proceed fast enough when stronger concentrations of gas commenced to be employed and hexamine was introduced into the fabric of the helmet. This afforded a means of practically adding ammonia to the mixture. The presence of additional mixture from the exhalations from the lungs favours the back reaction:—

$$4NH_3+6C_2HO \rightleftharpoons C_6H_{12}N_{14}+6H_2O.$$

The presence of the formaldehyde produced constituted a difficulty, for it slightly affected the lungs and eyes of the wearer.

In the case of hexamine the decomposition of phosgene is more direct, resulting in the formation of ammonium chlorine and urea:—

$$COCl_2+4NH_3 = CO(NH_2)_2+2NH_4Cl.$$

With the development of the latest respirator of the "helmet" type several mechanical improvements were devised. The original mica strip was replaced first by circular eye-pieces of glass, then by mica eye-pieces. An expiratory "flapper valve" was also provided, enabling

one to see much more clearly, and to breathe with greater ease and less discomfort from the heat.

Certain of the German "lachrymators," *e.g.*, monobromacetone, $CH_2Br.COCH_3$, were found to pass through the impregnated material previous to the first issues of the box respirators, and helmets fitted with goggles for the protection of the eyes were supplied.

Cloud gas and large-scale gas bombardments came to be employed so frequently, and such high concentration of gas was aimed at, that the "flannel bag" respirator, although made eventually of double thickness material, had to be abandoned in favour of the face piece and "filter tower" principle of the box respirator. Nevertheless, the old smoke helmets have served their purpose while they were required, although they have now been superseded by a more comfortable, efficient, and certainly more elegant production.

ABSOLUTE SCALES OF PRESSURE AND TEMPERATURE.

By F. J. W. WHIPPLE, M.A.

It has been suggested to me that it would be fitting to call the attention of members of the Physical Society to the adoption by meteorologists of new scales of pressure and temperature, and to canvass the advantages of bringing such into general use.

The fundamental reason for adopting an absolute dynamical unit for pressure lies in the fact that the variation of gravity from place to place on the surface of the globe is quite appreciable. In practical meteorology pressures are required accurate to one part in 10,000, so that the allowance for this variation, which is of the order ½ per cent., cannot legitimately be ignored. For many years it was customary to publish values of pressure in terms of the height of the barometer, making no allowance for this variation. In the meteorological charts, isobars were drawn to pass, not through places where the pressure was the same, but through places where the "head" of mercury was the same. A later development (which occurred in the British service in 1912) was to "reduce" the barometric readings to latitude 45°, the unit of pressure being the pressure due to an inch of mercury in latitude 45°. Such a unit is very artificial and is also irrelevant. The only satisfactory way to avoid the difficulty is to use absolute units which can be defined simply in terms of force and area.

The fundamental unit which has actually been adopted is the bar, the pressure due to a million dynes per square centimetre. The practical unit for meteorological work is the millibar, or 1000 dynes per square centimetre. This unit is rather more than the gravitance of 1 grm. per square centimetre; it would be exactly the gravitance of 1 grm. per square centimetre at a place where the acceleration due to gravity was 1000 cm./sec.². It is worth noticing that the millibar would be the pressure due to 1 cm. of water at maximum density at a place where gravity had this value.

It is necessary to emphasise the fact that the bar is not the same as the standard atmosphere used hitherto by the chemist, 760 mm. of mercury at 0° C. in latitude 45°. Actually the bar is equivalent to 750·076 mm. of mercury under those conditions. (This relation is derived from the equations $g_{45} = 980.617$ cm./sec.²; density of mercury at normal freezing-point of water = 13·5955 grm./cm.³. Conversion tables for pressures will will be found in the Computer's Handbook of the Meteorological Office).

The millibar is now in use, not only throughout the British Meteorological Service, but also in France. Other countries are gradually adopting it. It should be mentioned, however, that a different nomenclature is advocated by Prof. McAdie, of Blue Hill Observatory, which is attached to Harvard University. He wishes the name bar to be utilised for 1 dyne/cm.², so that our millibar would become the kilobar. He bases his advocacy on the tentative practice of a few chemists, but the weight of practical experience is in favour of the larger fundamental unit.

Instrument makers are now familiar with the graduation of barometers in millibars, and it is to be hoped that such instruments will shortly be introduced into all physical laboratories.

Another movement which was inaugurated about the same time as the first introduction of the millibar was that in favour of the everyday use of the absolute scale of temperature. The customary scales of temperature involve the frequent introduction of negative temperatures which are thoroughly illogical. With a scale such as the centigrade we are met with the paradox that −272° C. has a definite meaning, whilst −274° C. is unthinkable. It is hardly necessary to point out to the Physical Society that in thermodynamics it is always absolute temperature which counts. In meteorology we have to consider certain practical aspects of the question. In the first place, as may be seen in the accompanying diagram, the range of temperature with which modern meteorology, whose province is the whole atmosphere, is concerned goes from 180a to 330a (−130° F. to 130° F.), so that in many investigations negative temperatures would abound if the Fahrenheit or centigrade scales were used. (Sir Napier Shaw advocates writing 180a rather than 180° A. on the ground that the degree symbol ° should be reserved for angles). And in the second place, on the theoretical side, the application of the law of gases is so frequent that the use of the absolute scale leads to a direct economy of thought.

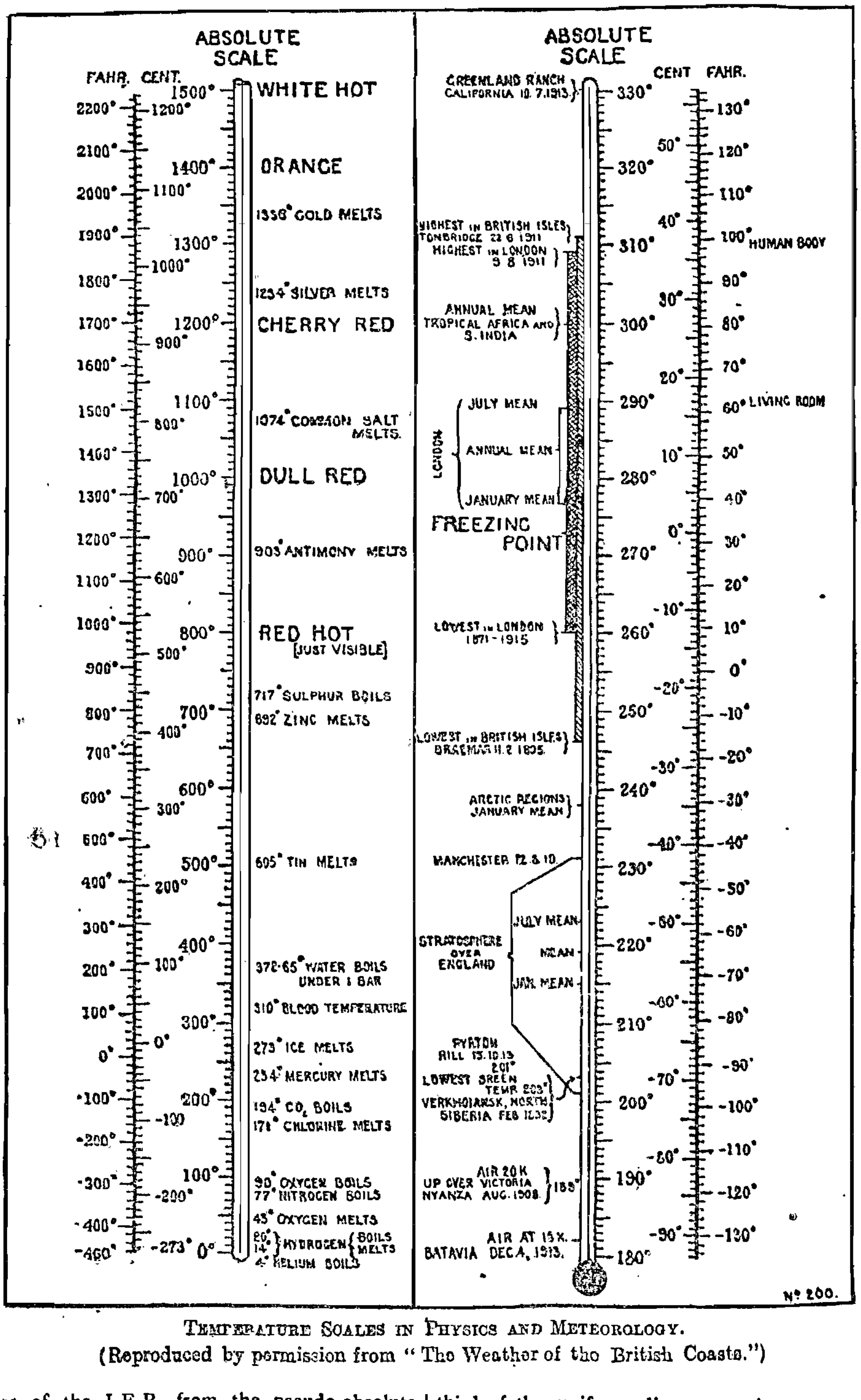
The temperature scale which has actually been adopted by meteorologists is derived from the centigrade by the addition of exactly 273°. This scale is not, strictly speaking, identical with the absolute centigrade scale, since the position of the absolute zero is not precisely −273·000° C. The meteorologist's scale has been called by some the pseudo-absolute scale. Sir Napier Shaw has introduced the name tercentesimal scale, on the ground that 300a falls within the range of temperatures to which we are accustomed.

Authorities differ as to the position of the absolute zero on the centigrade scale. The determinations quoted by Kaye and Laby ("Physical and Chemical Constants," 3rd edition, 1918, p. 44) vary from −273·05 to −273·27. The general mean is given by these authors as −273·13.

	Absolute centigrade.	Pseudo absolute.	I.F.P.
Absolute zero	0	−0·13	0
F.P. of mercury	234·26	234·13	234·15
F.P. of water	273·13	273·00	273·00
B.P. of water under 1013·2 mb.	373·13	373·00	372·95
" " 1015·1 mb.	373·18	373·05	373·00
" " 1000·0 mb.	372·78	372·65	372·60
B.P. of sulphur..	717·8	717·7	717·5

Accepting this mean result for the present, we see that on the true centigrade-absolute scale normal freezing-point is 273·13, while the same point is 273·00 on the pseudo-absolute scale. The few certificates issued by the National Physical Laboratory for absolute thermometers refer, I believe, to the pseudo-absolute scale, though there is no explicit evidence to that effect on them. The convenience of the adoption of 273a for the freezing-point rather than 273·13a cannot be gainsaid, and it may be desirable to regularise the position by defining a slightly modified scale of temperature such that 0 is the absolute zero and 273 is the normal freezing-point. The degree of this new scale, which may be designated the I.F.P., or integral-freezing-point scale, provisionally, will be slightly less than the centigrade degree. The difference is so small, however, that hardly any measurements will be affected appreciably. For example, throughout the range of temperature of ordinary meteorological thermometers

SCALES OF PRESSURE AND TEMPERATURE.



TEMPERATURE SCALES IN PHYSICS AND METEOROLOGY.
(Reproduced by permission from "The Weather of the British Coasts.")

the departure of the I.F.P. from the pseudo-absolute scale is less than 0·03° C. Even at the boiling-point of water under standard conditions the discrepancy between these two scales is only 0·05° C., and, therefore, only a third of the uniform discrepancy between the absolute centigrade and the pseudo-absolute scales.

The I.F.P. scale has for its fundamental fixed points zero and 273. The boiling-point under any specified pres-

sure may be regarded as a secondary fixed point and used for calibrating thermometers. As will be seen from the table, the temperature 373 may be fixed as the boiling-point under 1015·1 mb.

The general adoption of the absolute scale for popular use in the near future is not to be anticipated, but there seems to be no good reason why it should not find a place in the physical laboratory at once. Thermometers are always being broken and replaced, and therefore the substitution of the absolute for the centigrade scale may well be a gradual process.—*Proceedings Physical Society*, xxxi., Part 5.

THE PEPPER TREE (*SCHINUS MOLLE*) IN ITS RELATION TO EPIDEMIC HAY FEVER.*

(INTERIM REPORT).

By Prof. GEORGE POTTS, M.Sc., Ph.D.

FOR several years past epidemic hay fever has been very prevalent in Bloemfontein and many other up-country towns, and the Pepper Tree is commonly held responsible for the disease. In Bloemfontein the epidemic attacks such a large proportion of the population, especially in early summer after windy weather, and causes so much discomfort and even misery, and the belief that the Pepper Tree is to blame is so widespread that the Town Council considered the advisability of eradicating the tree from the town, and in December, 1917, circularised the local medical practitioners for an expression of opinion as to whether the Pepper Tree is to blame for the epidemics. Two doctors were strongly of opinion that the Pepper Tree is the main cause of the disease, whilst five considered that it might be one of many causes, but pointed out that the matter had not been adequately investigated, and that it would be extremely inadvisable to remove a tree which does so much to beautify the town, until the case against it has been definitely and scientifically proved.

Dr. Targett Adams, M.R.C.S., D.P.H., Assistant Medical Officer of Health for the Union, suggested I should investigate the question, and I am also indebted to him for guidance and very material assistance during the course of the investigations. As it is a matter which concerns the public health, he himself, and his Department, are vitally interested in it.

Examination of Flowers.—As a first step the flowers were examined for the purpose of ascertaining whether the pollen is carried from flower to flower by the wind or by other agencies. It is well known that there are two sexes in the Pepper Tree. The fruit-bearing, or female, tree bears only female flowers. These have a prominent honey-gland, a pistil with three viscid stigmas and ten stamens. The anthers, however, contain no pollen, and are white and empty—botanically they are called staminodes. The male tree bears only male flowers. These also have a prominent nectary which secretes honey profusely, and ten fertile stamens, whose anthers are filled with golden-yellow smooth-grained pollen. There is also an abortive pistil. The pollen is very adhesive; it sticks together in balls, and in a mature flower the anthers themselves are often stuck together in groups by means of their pollen. Moreover, when pollen is dropped on to smooth paper, or even on smooth clear glass, it adheres so tenaciously that it is impossible to blow it off with the mouth. The pollen, moreover, is not shed from, nor does it fall out of the anthers. If flowering shoots from a male plant be placed in water it will be found that after the anthers open the male flowers drop off with the pollen still contained in the anther-cells. The same thing happens to flowers left on the trees, and if the minute white flowers which are to be found under male trees almost all through the summer be examined it will be found that the anthers are invariably still full of pollen, which is easily recognised by its deep golden-yellow colour.

The conspicuousness and non-green colour of the flowers, the presence of abundant honey, the sticky pollen and viscid stigmas all point to insect-pollination, and, indeed, insects are frequently to be seen visiting the flowers.

The evidence obtained by an examination of the flowers is thus all against the likelihood of the pollen being carried by the wind. Indeed, if it were carried one would expect to see it in the air, especially when it is remembered that each of the numerous small male flowers has ten fertile stamens.

In the Pine, which is wind-pollinated, the pollen can often be seen floating in the air around the trees when the stamens are ripe, and if a branch be shaken when the tree is in flower a veritable shower of sulphur-coloured pollen is produced. The same is true of the numerous other ornamental conifers so commonly grown in garden and parks. But the Pine pollen is dry and powdery and does not stick together, and its carriage by the air is facilitated by the grains being winged. The flowers are also inconspicuous and have no honey. The Pepper Tree, on the other hand, is undoubtedly insect-pollinated; the pollen is sticky, adheres together in balls, and is carried from flower to flower, stuck to the bodies of insects.

Hay Fever and Pollen in U.S.A.—Hay fever caused by pollen is very prevalent in America, and there exists there a society for its prevention, called the American Hay Fever Prevention Association. The plants which cause the disease are all wind-pollinated and are mostly common weeds, and experience has shown that eradication of the pollen-producing plant is the only method of dealing with the disease which has given satisfactory results. The objects of the Association are to educate the public as to the relationship between the weeds concerned and hay fever, and to bring about legislation for the eradication of the weeds. Such an "anti-hay-fever-weed law" has been passed by New Orleans, and since being enforced there has been a great reduction in the number of hay fever cases.

In an article by Dr. W. Scheppegrell, President of the Association, which appeared in the *Scientific American Supplement*, August 12, 1916, emphasis is laid on the statement that all the plants whose pollen causes hay fever in America are wind-pollinated. The majority of the plants implicated, as has already been stated, are common weeds, and it should be noted that many of these are plentiful in and around Bloemfontein and other South African towns. They are common in back-yards, on vacant erven, along the side of our streets, in sluits, and as weeds on cultivated ground. If their pollen is injurious in America it is probably equally so in South Africa, in which case much of our epidemic hay fever may quite well be due to these weeds.

Grasses, which, too, are wind-pollinated, have been shown to cause the disease in America, and the researches of Dr. Blackley, of Manchester (himself a sufferer), have placed this beyond doubt in his own case. (I am indebted to Dr. Targett Adams for this reference). He also showed that the pollen from Pine trees is very powerful in its effect.

But all the plants which have hitherto been shown to cause the disease are plants whose pollen is normally carried by the wind, and it would be something new to science to find the disease caused by pollen which is carried from flower to flower by agencies other than the wind.

Though the opinion that the Pepper Tree is the cause of our epidemic hay fever is so widespread it should be noted that none of the evidence in favour of the opinion is convincing. It has been stated that (letter from Dr. S. M. de Kock, M.B., Ch.B., to Town Clerk, December 31, 1917) "before Pepper Trees were extensively planted in Bloemfontein hay fever as an epidemic was unknown," and that the introduction of the epidemic has "followed

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* From the *South African Journal of Science*, xv., No. 7.

the extensive planting of the Pepper Tree in Bethulie, Kimberley, and other towns." On the other hand, it should be noted that Pepper Trees are very plentiful in both Grahamstown and Maritzburg, and yet in neither town is epidemic hay fever existent. Again, though it is maintained that "the start of the epidemic of hay fever is synchronous with the flowering of the Pepper Trees," my observations last season showed that the male trees were in flower intermittently all through the rainy season, until, in fact, the first severe frost.

Before considering some experiments with the Pepper pollen reference will be made to the aromatic principle contained in the trees.

The Pepper Tree is very rich in resin, and American mastic, a kind of resin, is obtained from it. There is a very large resin canal in the phloem of each bundle of the leaf, and one large and several smaller canals in the phloem of each bundle of the stem, and if either leaf or stem be injured the resin exudes as a translucent fluid, which gradually hardens and turns white on exposure to the air. The tree itself has a pungent and irritating odour which is very noticeable when working with injured portions of the plant, but it is extremely improbable that under ordinary conditions the volatile constituents of the resin are even present in the atmosphere in sufficient quantity to cause hay fever. Indeed, the odour is only noticeable out of doors within a few yards of the tree.

Experiments with Pepper Pollen.—Two of my colleagues, Prof. M. M. Rindl, D.Ing., and Prof. W. Conlin, M.A., who are hay fever sufferers, were sufficiently public spirited to allow me to experiment on them to ascertain whether pollen from the Pepper Tree would induce an attack of hay fever. Stamens with open anthers from male flowers were collected and carefully air dried, and the material was then lightly crushed to liberate the pollen grains. As a preliminary test each smelled the contents of the bottle after the bottle had been violently shaken. Neither experienced any ill-effects. If fresh pepper pollen were carried in the air the conditions of the experiment were such that some of the dried material would have remained in suspension in the air of the bottle sufficiently long to be inhaled.

After an interval of three or four days each snuffed up about as much dried pollen as would lie on a threepenny piece. The result in both cases was an acute attack of hay fever, which commenced after an interval of about six hours, and continued for between two or three days (forty-eight to seventy-two hours). The dose snuffed was probably excessive, but at this stage I was almost convinced that there was no truth in the widely held pepper pollen theory, and had the results been negative the experiment might reasonably have been regarded as giving the theory a knock-out blow.

The way in which the pollen provoked the attack must now be discussed. The pollen grains being smooth are not likely to produce much mechanical irritation, and two medical practitioners whom I consulted were of opinion that if the action of the pollen had been merely mechanical the attack would not have continued beyond about six hours.

According to Dr. Scheppegrell the irritant action of wind-borne pollen in causing hay fever is considered to be chemical, and the substances absorbed are thought to be proteids, preceded in the case of spiny pollen by a little mechanical irritation. Indeed, the action of pollen extracts as a preventive measure is based on an assumed chemical action of the pollen, the idea being gradually, and without inconvenience to the patient, to accustom his system to cope with these extractives. Prof. W. P. Dunbar, of Hamburg, who was one of the first to investigate the relation of hay fever to pollen, found that the disease is caused by the pollen of certain grasses, rye, and other plants, and he isolated from the pollen an albuminoid poison which when applied to the nose of a susceptible individual causes an attack, while there is no result in the case of a normal person. This proves that the action of the pollen was chemical. Prof. Dunbar was also able to show that the severity of the attack is directly proportional to the amount of pollen in the air (*Encycl. Brit.*, 11th Ed.).

For pollen to produce hay fever chemically a considerable amount would be necessary, and whilst in the experiment on Profs. Conlin and Rindl there was probably more than sufficient inhaled to make this mode of action possible, this method of producing the disease cannot be operative in the case of pepper pollen under natural conditions, as the pollen is not normally wind-borne.

The artificial conditions under which the experiment was performed should be kept in mind. The experiment merely proves that pepper pollen *can* produce the disease; but, though capable of causing hay fever, it may never do so under natural conditions.

There remains a third possibility, viz., that pepper pollen carries a bacterium, which, growing on the mucous membranes of the nose, produces the disease. On this assumption a single infected pollen grain would be sufficient to inoculate a patient and produce the disease. I am indebted to Dr. Targett Adams for most willingly allowing the experienced Bacteriologist of the Public Health Department, Mr. O. F. Gibbs, to make a bacteriological examination of the dried pollen which had produced the attack. Mr. Gibbs' report is as follows:—

Government Laboratories,
Department of Public Health, Bloemfontein.
June 25, 1918.

With regard to the "Pollen" which you asked me to investigate, from a bacteriological point of view, the following results have so far been obtained:—

Some of the samples was sown in "Peptone beef broth," and after forty-eight hours' incubation at 37° C. quite a dense growth was obtained. The culture was then "plated out" on ordinary agar, and after twenty-four hours' incubation two varieties of colonies had appeared, viz.:—

No. 1, a greyish coloured colony about ½ mm. in diameter.

No. 2, a whitish coloured colony about 1½ mm. in diameter.

Microscopic examination showed in each case a distinct diplococcus, resembling two beans placed side by side with the concave margins adjacent. No. 1 is a rather small diplococcus, whilst No. 2 is somewhat larger. Both stain readily with carbo-thionin blue, and are "grm.-positive."

Before these can be classified in any particular group, other tests will have to be carried out, animal and fermentation tests.

Whether these organisms have an affinity for pollen and whether they are the infecting agent in "hay fever" remains to be proved.

Some time ago I had occasion to prepare autogenous vaccines for two cases (Nos. 34 and 35) suffering from an acute attack of "hay fever." The material was obtained from the "nasal discharge," and in each case the predominating organism was a "grm.-positive" diplococcus having the same microscopic characters as Nos. 1 and 2.

One cannot place too much reliance on two cases, and I would like to suggest that a series of experiments be carried out on different pollen from different sources, preferably in the summer, when we could have a much greater choice.—I am, yours very sincerely,

(Sd.) O. F. Gibbs,
Government Bacteriological Assistant,
late of the Lister Institute of Preventive Medicine, London.

Mr. Gibbs' results are of great interest, and open up a new field for investigation. The dried pollen was found to carry two species of diplococcus bacteria, and bacteria with similar microscopic characters had already been found by Mr. Gibbs the previous summer (January and April, 1917) in the nasal discharge of two Bloemfontein patients suffering from an acute attack of hay fever.

Here may lie the clue to the solution of the problem of the relation of the Pepper Tree to epidemic hay fever, if there is any such relation, in which case the sufferings of Dr. Rindl and Prof. Conlin will not have been in vain. On the other hand, it should be explained that there are hundreds of species of diplococcus, and that though the species found on the pollen and in the nasal discharge are morphologically similar they may quite well be physiologically very different. It should also be added that the pollen was not removed from the Pepper Trees with the usual bacteriological precautions.

Experiments have been started to test the disease-producing power of the diplococci, and if they are found capable of producing the disease, experiments with proper bacteriological precautions will be made to ascertain whether they are always found on the pepper pollen and where else they occur. The diplococci concerned may be of very general occurrence in the air and dust of Bloemfontein, and may live normally in the nasal discharge of inflamed mucous membranes without causing injury to the patient, *i.e.*, their presence in the case of hay fever may be the result of the disease rather than its cause.

Although the investigation is far from concluded it has been considered advisable to present an Interim Report at this stage because of the great interest taken in the question by the general public. It is hoped to continue the investigations next summer in collaboration with the Public Health Department, when it is intended to attack the problem from several points of view. The pepper pollen clue will be followed up, and special attention will be given to common local weeds, grasses, and other plants whose pollen is normally carried by the wind.

Appeal for Co-operation.

(Issued through the local Press to the public of Bloemfontein).

Assistance is invited in solving the problem. Volunteers who are willing to allow themselves to be inoculated to test whether the diplococci isolated are capable of causing hay fever should communicate with Mr. O. F. Gibbs, Public Health Department, Government Buildings (Tel. No. 18). Only persons susceptible to the disease are suitable for experiment.

If doctors who have patients suffering from an attack, or the patients themselves, will report cases to me as early as convenient, I will endeavour to visit the house or place of work and record the plants flowering in the immediate neighbourhood at the time. It will be sufficient to supply the name and address of the sufferer either in writing to 91, Park Road, or by telephone (253). A statistical treatment of a large number of cases may disclose the cause of the trouble. It is also hoped to make a bacteriological examination of the nasal discharge of several patients.

Botanical Department,
Grey University College, Bloemfontein.

THE USE OF ELECTRICITY IN AGRICULTURE.*

WITH SPECIAL REFERENCE TO ITS DEVELOPMENT IN GERMANY.

By JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

AGRICULTURE is almost certainly the oldest human industry, and the stage in its development when animal power was introduced to aid human endeavour is not traceable in recorded history, nor is tradition helpful on the point. We know that the Egyptians employed querns driven by oxen for the grinding of corn, while oxen, asses, and horses were employed from very early days for the hauling of ploughs and rollers, and for the transportation of farm produce.

The use of water-power for irrigation and drainage, and the employment, about the opening of the twelfth century, of wind-power for the same purpose, form the first introduction of mechanical power into agriculture, and with the sole exception of its use for driving corn-grinding machinery, this was, for all practical purposes, the extent of its application until the invention of the threshing machine, to which written reference is first found in 1743. The first threshing machines were driven by water-power, though later Boulton and Watt steam engines were employed. There was little further development in the application of mechanical power until the middle of the nineteenth century, which, to quote the United States Twelfth Census Report, "practically marks the close of the period in which the only farm implements and machinery, other than the wagon, cart, and cotton gin, were those which, for want of a better definition, were called implements of hand production."

At this period efforts were made to introduce steam-power into farm work. Steam tractors were devised for the operation of portable farm implements, but without much success. Greater success attained the introduction, about 1855, of the well-known Fowler steam plough, which consisted of haulage gear by which a single portable steam engine of the type used for threshing, stationed at one side of the field to be ploughed, hauled, by means of a steel rope, a large plough from one side of the field to the other.

Modifications were introduced into this system of ploughing, such as, for instance, the "roundabout" system invented by Fisken, who is also responsible for the arrangement by which the haulage gear was automatically moved forward after each set of furrows had been ploughed, but the most definite advance was the introduction, again by Fowler, in 1865, of the two-engine system in which two portable engines were employed, the one to haul the plough in one direction, and the other in the opposite direction, across the field to be ploughed.

Experiments were made in 1893 with tractors fitted with internal-combustion engines for the direct hauling of ploughs and cultivators, but it was not until 1903 that the difficulties met with could be said to have been satisfactorily overcome. A large number of these tractors are in use in America, and conditions created by the war have caused them to be introduced in large numbers into the United Kingdom.

The first application of electricity to farm work to which the writer can trace any reference was in 1879 ("La Lumière Electrique," June 15, 1879), when Gramme electric motors were employed in France to replace the steam engines, in the two-engine ploughing system introduced by Fowler. These motors, as in the systems of Fowler and Fisken, operated not only ploughs, but harrows, weeding, sowing machines, &c. The application of electricity, made by Chrétien and Félix, showed considerable enterprise, considering the early stage in the development of electrical engineering at which it was made.

Electricity to-day finds many applications in agriculture, including :—

(*a*) The lighting of homesteads, farmyards, and buildings.

(*b*) The provision of power through the medium of—

(1) Non-portable motors for the operation of stationary machines, as dairy machines, corn-grinding machinery, &c.; of—

(2) Portable motors for the operation of portable machines, such as ploughs, harrows, &c., and of stationary machines which run too intermittently to justify separate motors.

(*c*) The provision of transport facilities either through electrically-operated light railways, tramways, railless traction, or self-propelled electrical vehicles.

* Reprinted by permission from the *Journal of the Royal Society of Arts*.

(*d*) The production of artificial fertilisers, more particularly through the fixation of atmospheric nitrogen; and

(*e*) The direct application of electricity to growing crops, a subject which is at present being investigated by a Special Committee. (Committee formed by the Conjoint Board of Scientific Societies under the auspices of the Royal Society).

It is proposed to confine this paper to the use of electricity for purposes of light and power. It will, however, be borne in mind that the economic provision of electricity for light and power in rural districts may be, and frequently is, almost wholly dependent on the demand created by more concentrated industries. Thus the demand for electricity at a large chemical works, at a point distant from a central station, may necessitate the running of a transmission line which rural demands alone would never justify, while a transmission system for electrical traction can supply the rural area through which it passes with electricity for purposes other than transport.

In recent years the greatest advance in the application of electricity to agriculture has taken place in Germany, in the United States, in Canada, and in Spain. Germany has been far in advance of other countries in this interesting application of electricity, and it was felt that a description of the development there, which the writer had an opportunity of examining immediately prior to the war, might be helpful in encouraging a demand for electricity for farm work, while such a demand should have an important bearing on the development of electricity supply in rural districts.

Introduction.

It is well known that owing to the increasing scarcity of labour, rise in wages, and in the cost of land, and owing also to the increasing significance of foreign competition in the world's markets, German agriculturists were, in the years prior to the war, employing machinery to a continually increasing extent.

Thus between 1895 and 1907 the number of steam or motor threshing machines increased from 259,364 to 488,867 ("Report to the Board of Agriculture and Fisheries," by J. H. Cahill, 1913); of other threshing machines, 596,869 to 947,003; sowing machines, 169,465 to 290,039; mowing machines, 35,084 to 201,325; milk centrifugals, 87,987 to 339,906; steam ploughs, 1696 to 2995.

As showing the effect of the introduction of machinery and improved methods into agriculture, it is interesting to note that whereas "in 1855 four hours and thirty-four minutes' labour was required to produce a bushel of corn, in 1984 the average time was reduced to forty-one minutes" ("Electricity on the Farm," 1913, General Electric Company, New York).

It is further stated in the "Year Book of the United States Department of Agriculture, 1899," that "it formerly required eleven hours of manual labour to cut and cure a ton of hay, whereas the same work is to-day accomplished, with the aid of machinery, in one hour and thirty-nine minutes, the labour cost being reduced from 83½ cents to 16½ cents per ton."

Power of some kind is necessary for carrying out all work, and for the operation of agricultural machinery mechanical power has to be provided where human and animal power are not employed.

Manual labour offers the dearest and least continuous source of power, particularly at the present day, when, owing to the competition of other industries, labour in agricultural districts is becoming every day more scarce and dear. By preference, for agriculture, animals are used as a source of power; but when compared with sources of mechanical power they have this disadvantage, amongst others, that they as well as human beings do not work at a uniform rate, while their support during the necessary periods of rest, or of enforced idleness due to illness, involves considerable expense.

Mechanical power also enables work to be done that could not otherwise be handled, while the greater power available and the higher speeds enable more work to be done in a given time and at less cost than is possible with animal labour. It should also be borne in mind that the elimination of animal power from farm work would enable millions of acres at present devoted to the raising of food for fodder to be devoted to more productive purposes. It is estimated that only from 6 to 10 per cent of the heat value of the food consumed by animals is returned as work, while from records made by the United States Government it would appear that on the average a farm horse does not work more than three hours per day, the pre-war cost of his labour being estimated at 8 to 13 cents per hour. This figure would, of course, be very much higher to-day owing to the great increase not only in the first cost, but in the up-keep of the animals. In comparing this figure with costs of mechanical power it should be remembered that the figure taken by James Watt as the power of an average horse, viz., 33,000 foot lb. per minute, is on the high side, probably intentionally so. The average horse works at the rate of approximately two-thirds of one brake horse-power.

As sources of electrical power the farmer has at his disposal wind, water, and heat. The wind can be utilised by means of windmills, and is used in many cases, particularly for purposes of irrigation or drainage, but on account of its uncertainty and the low powers generally available it need not be seriously considered for agricultural purposes. Water-power is of considerably more importance in connection with farm work, and might be used to a far greater extent than at present in this country. It is worthy of note that one firm alone installed (see *Electrical Review*, lxxxiii., No. 2127, August 30, 1918) in North Wales between 1907 and 1917 not less than 234 water-power installations for farm power and lighting, varying in horse-power from a maximum of 9 h.p. to a maximum of 1 h.p. This important development in the use of water-power for small farms in this area can be taken as an indication that its value was realised by the farmers.

For the production of power from heat the farmer can choose between engines using coal, peat, oil, and, in some isolated instances, gas. It was early realised in Germany that mechanical power developed from any of the sources to which reference has been made was, in general, only available at the particular place of generation and in the immediate neighbourhood, as the transmission of mechanical power to any distance by mechanical means is not a practical proposition.

Portable steam engines have, of course, been in use a great many years for the driving of threshing machines, &c., and portable oil engines have recently been introduced on a limited scale for farm work. The fact that these engines are portable, however, limits their weight, and since heat engines have a high weight per h.p. this limits the power that can be developed by them.

Since it is particularly characteristic of agricultural work that a considerable proportion of it has to be carried on, not necessarily close to any particular source of power, but over a more or less wide area, farm conditions could only be met, so far as power is concerned, by the use of the portable engines above referred to, and, as we have seen, their power is limited by the weight it is possible to transport over soft agricultural ground, and their use by the fact that fuel and in most cases water have to be brought to them.

It was these limitations that led to the development in the use of electricity which has been so notable a feature of agricultural work in Germany of recent years. In many large farms the farmer generates by means of one or other of the sources of power referred to the electricity he needs for his farm work. By far the greater amount of power, however, used electrically on farms in Germany is distributed from central stations.

It was early realised that power generated in a central

station was considerably cheaper than power generated in a small private plant, because the centralisation of the power plant resulted in a saving in wages, maintenance, and running costs, &c., and rendered it possible to employ large generating units which were much more efficient, while since a large number of different consumers take their power from the same central station, the maximum demands of each consumer for power would not occur at the same time, and therefore smaller plant could be installed to meet these various demands than would be necessary if each separate consumer had to instal his own plant. In general it may be said that the more varied and numerous are the demands for power in any district the better is the case for the generation of that power in a central station. It is also worthy of note that every large consumer who takes his power from a central station, particularly if his load factor is good, as is particularly the case with chemical works, enables the cost of power to all the other consumers on that station to be reduced.

Owing to their comparative unimportance no attention has been given in this paper to the distribution of power for agricultural purposes by means of gas, air, steam, &c., by water or by shafting, belts, ropes, &c. Where electricity is generated on the farm itself it has to be distributed by means of a low-tension electrical transmission system to the various points on the farm where it is required, or, in exceptional cases, where the farm is particularly large, by means of a high-tension transmission system to certain points, low-tension mains being used for local distribution from these points.

Where electricity is distributed from a long distance central station the electricity is transmitted by high-tension transmission lines to various points, and usually by transmission mains of medium tension to the various farms, and from these medium tension mains current is taken for use on the farm where required in a manner which will be described later.

The use of electric current for light and power made little progress among farmers in Germany until the advantages associated with it became fully known. As has not infrequently been the case in connection with electrical developments, the first use of electricity for farm work was for lighting, and it was the addition of small motors to lighting installations that first popularised the employment of electricity for power purposes. The mistrust of the farmer had almost completely disappeared before the war, and the chief production of electrical power in central stations, and its transmission by carefully designed transmission systems in the various parts of the country, coupled with the great increase in the number of these stations, now give the German farmer an opportunity of advantageously introducing electricity into his farmyard and field, for lighting his buildings, and driving his various machines, thus enabling him to do his farm work in a more favourable manner and rendering him more independent of daylight and weather conditions.

This development has been encouraged by the increasing scarcity of labour and its increasing cost, as well as the increase in first cost and maintenance of haulage animals, all of which had been making it more difficult for the German farmer to secure a satisfactory return on his outlay.

The development of electricity enables the farmer to do as much of his work as possible independently of human labour, and by the great development in the design of motors technically suitable for agricultural purposes, the charges for attendance cost have been reduced and the portability of the machines greatly increased.

In general, it may be said that the introduction of electric driving into German agriculture has meant a reduction in the total working power required on the farm, has enabled the farmer to use his agricultural machines for a longer period, effect a reduction in the number of workers employed, and secure the production of farm produce in a better manner than before.

(To be continued).

FUEL ECONOMY.*

Introduction.

Soon after the Committee had drawn up its First Report, which was presented at the last meeting of the Association at Newcastle-on-Tyne in 1916, certain important developments took place in regard to the subject of its inquiry which it seems desirable now briefly to recount.

In July, 1916, largely as the result of the work of the Committee, the Government, having at length realised the importance of the problem of fuel economy, appointed what afterwards became the Coal Conservation Committee of the Ministry of Reconstruction, under the chairmanship of Lord Haldane. Altogether seven of the then members of this Committee were invited, in their individual capacities, to serve on the Government Committee. An advance copy of the First Report was placed at Lord Haldane's disposal for the information of his Committee, which ultimately issued its Report and concluded its labours in 1918.

One of the first acts of the Coal Conservation Committee was to memorialise the Advisory Council (afterwards the Department) of Scientific and Industrial Research as to the need of a Chemical Survey of British Coalfields, a proposal which, it may be pointed out, had originated with this Committee, and had already been strongly urged in its First Report.

Matters having thus progressed so far, and it being clear that nothing further could be done without considerable grants of money, steps were taken, with the concurrence of the Council of the Association, to ascertain the attitude and intentions of the Advisory Council for Scientific and Industrial Research towards fuel research, and in what way, if any, the work of this Committee could be assisted and co-ordinated with that of other similar bodies concerned in the matter.

On November 2, 1916, an informal conference was held at the Board of Education between representatives of this Committee and of the Advisory Council, with a view to arriving at some mutually satisfactory arrangement whereby the work of the Committee would be taken over and continued under the ægis of the new Department of Scientific and Industrial Research. It was then represented, on behalf of the Advisory Council, that it was their intention to set up, in the near future, a new Standing Committee on Fuel to organise and carry out, with adequate financial provision, the various lines of research already recommended by this and Lord Haldane's Committee, and that they desired to take over and incorporate in some way with the proposed new organisation the more active members of this Committee. Unfortunately, however, the plan then proposed for so doing (which would have been entirely acceptable to this Committee) was eventually set aside by the Department, which, in February, 1917, established its own Fuel Research Board on a different basis. As it soon became clear that the new Board did not desire any assistance from an outside Committee, no basis of co-operation could be arranged, although the Committee had intimated to the Director of Fuel Research its willingness to collaborate.

For a period of a year afterwards the Committee did not meet, and its work was suspended, although a nucleus

* Second Report of the Committee, consisting of Prof. W. A. Bone* (Chairman), Mr. H. James Yates* (Vice-Chairman), Mr. Robert Mond* (Secretary), Mr. A. H. Barker. Prof. P. P. Bedson. Dr. W. S. Boulton, Mr. E. Bury, Prof. W. E. Dalby, Mr. E. V. Evans,* Dr. W. Galloway, Sir Robert Hadfield, Bart.,* Dr. H. S. Hele-Shaw,* Mr. D. H. Helps, Dr. G. Hickling, Mr. D. V. Hollingworth, Mr. A. Hutchinson,* Principal G. Knox, Mr. Michael Longridge, Prof. Henry Louis,* Mr. G. E. Morgans, Mr. W. H. Patchell,* Prof. L. T. O'Shea, Mr. E. D. Simon, Mr. A. T. Smith, Dr. J. E. Stead, Mr. C. E. Stromeyer, Mr. G. Blake Walker, Sir Joseph Walton,* Prof. W. W. Watts,* Mr. W. B. Woodhouse. and Mr. C. H. Wordingham,* appointed for the Investigation of Fuel Economy, the Utilisation of Coal, and Smoke Prevention. (The * denotes a Member of the Executive Committee). Read before the British Association (Section B), Bournemouth Meeting, 1919.

of its members informally kept in touch with developments. In October, 1918, however, in response to a widespread and growing feeling that there was need of an organised body of independent scientific opinion that could be brought to bear, in the public interest, upon any proposals for research of public policy with regard to fuel, the Committee resumed its labours, having been empowered by the Association to reorganise its work and personnel, to enter into communication, at its discretion, with Government Departments, the Federation of British Industries, and other bodies concerned with fuel economy, and to publish from time to time through the medium of the technical Press, or otherwise, any information or recommendations in the national interest, without prejudice to the presentation of its Report to the Association.

Reorganisation.

The reconstituted Committee comprised thirty instead of (as formerly) forty-five members, and the number of the Sub-Committees was reduced from five to three, each with its own Chairman and Vice-chairman, as follows:—

A. Chemical and Statistical, 12 members; Prof. Henry Louis, Chairman; Prof. W. W. Watts, Vice-Chairman.
B. Carbonisation and Metallurgical, 9 members; Sir Robert Hadfield, Chairman; Mr. A. Hutchinson, Vice-Chairman.
C. Power, 10 members; Mr. C. H. Wordingham, Chairman; Mr. W. H. Patchell, Vice-Chairman.

Each of the following Societies and Institutions was invited to nominate for co-option (if not already a member) a representative on the Committee, which they did, as follows:—

1. Federation of British Industries—Mr. A. T. Smith.
2. Association of British Chemical Manufacturers—Mr. Robert Mond.
3. Society of Chemical Industry—Mr. E. V. Evans.
4. Institution of Mechanical Engineers—Mr. W. H. Patchell.
5. Institution of Electrical Engineers—M. C. H. Wordingham.
6. Institution of Mining Engineers—Mr. G. Blake Walker.
7. Institution of Mining and Metallurgy—Mr. G. E. Morgans.
8. Iron and Steel Institute—Sir Robert Hadfield.
9. Coke Oven Managers' Associations—Mr. D. V. Hollingworth.

In addition, Mr. D. H. Helps has continued to represent the Institution of Gas Engineers, and Mr. H. James Yates the Society of British Gas Industries.

Finally, an Executive Committee of twelve members was appointed, including *ex-officio* the Chairman, Vice-Chairman, and Secretary of the General Committee, the Chairman and Vice-Chairman of each Sub-Committee, and in addition one other representative member from each Sub-Committee.

Since its reconstruction the General Committee has held four meetings, whilst the Executive has met seven times. In view, however, of the vastness and complexity of the manifold issues involved in the present coal situation, and the difficulty of formulating any definite conclusion as to the effects of the war until conditions have become stabilised once more, the Committee decided to postpone presenting any final Report until some future year. The present Report is, therefore, of an interim nature, concerning such items only as appear to warrant publication at this juncture.

Coal Outputs and Prices since 1913.

In its first Report the Committee drew attention to the vital importance of relatively cheap coal to the nation's industrial prosperity, and stated that, for some years before the war, the average price of coal at the pithead had been decidedly on the up-grade, a tendency which might be expected to continue at an accelerated rate. As the result of circumstances created by, or arising out of, the war, the average pithead price of coal has already almost trebled since the year 1913, and is likely to rise still higher, a matter of most serious concern to the whole nation.

How basic is the necessity of relatively cheap coal to the recovery of our pre-war prosperity will at once be apparent when it is realised how absolutely dependent are all our principal manufacturing industries upon imported raw materials. Our own natural resources do not enable us to provide ourselves, in quantity sufficient for the needs of a modern industrial community, with a great variety of raw materials; nor can we grow sufficient food for our present population. But our ships can bring abundance of raw materials from all parts of the world to our coal. Without the impelling power of relatively cheap coal, we should neither be able to attract the raw materials, nor yet to build or maintain the ships in which to convey them. Relatively cheap coal is, in fact, a fundamental necessity to the maintenance, not only of our great iron, steel, engineering, shipbuilding, and textile industries, but of our shipping trade and sea power.

Thus in 1913, the chief raw materials which we produced in excess of our requirements were coal, clay, and salt. By far the most important of these was coal, of which we exported 97·5 million tons valued (f.o.b.) at 52 million pounds sterling. Half of the 10·5 million tons of iron smelted in our furnaces was from imported ores. We imported also the whole of the copper and cotton, 95 per cent of the zinc, 90 per cent of the lead, and about 80 per cent of all the wool and timber used in British industrial establishments. In addition, we imported some 257 million pounds' worth of food, drink, and tobacco.

The great need of the moment is that the true facts of the situation shall be brought home to all sections of the community. The Committee, therefore, desires to draw attention to the comparative data concerning the movement of coal prices in Great Britain and the United States during the war period (Table I.). The British figures are all derived from official, or other equally reliable sources, whilst those relating to America have been extracted from the Bulletins issued by the Bureau of Labour Statistics (U.S. Department of Labour), to which the Committee desires to acknowledge its indebtedness. In converting the American prices into their English equivalents a dollar has been taken as 50 pence.

Table I.—*Outputs of Coal and Average Pithead Prices in Great Britain.*

Year.	Total Output Million Tons.	Annual Output per person employed (Tons).	Average Pithead Price Per Ton. s. d.
1913	287·4	260	10 1
1914	265·6	238	10 2
1915	253·2	270	12 6
1916	256·3	260	15 7
1917	248·0	247	16 9
1918	227·7	232	(24 0) (*a*)

Prices per ton paid by Consumers in Great Britain.

Year.	In London for best House Coal delivered. s. d.	For Gas Coal by the South Metropolitan Gas Co.: f.o.b. at N.E. Coast. s. d.	For Gas Coal by the South Metropolitan Gas Co.: Cost into Works. s. d.	For Durham Coal Coking at a Cleveland Ironworks. (*b*) s. d.
1914	29 0	11 2	14 6	13 0
1915	34 3	15 5	22 11	16 2
1916	37 0	16 5	26 4	22 3
1917	38 0	16 8	32 5	22 10
1918	44 0	20 11	34 4	24 5

(*a*) Estimated.
(*b*) The corresponding pithead prices would be about 3s. 6½d. less than these. The average price (at the works) during the first six months of 1919 has been 26s. 6d. per ton.

The upward tendency of prices has continued since the close of 1918, and, according to a recent declaration made on behalf of the Government in the House of Commons, consumers will have to face an all-round increase on the foregoing prices of 6s. per ton during the coming winter.

The Committee views with concern the recent rapid decline *of the annual outputs per worker employed in* British mines. During the thirty years preceding the war the returns had showed a steady decline, as follows :—

Decade.	Average Annual Output per Worker (Tons).
1883-92	320
1893-02	295
1903-12	280

That this downward tendency was peculiar to British mines is shown by the comparative figures given in Table II.

TABLE II.—*Comparative Annual Outputs per Worker employed in the Mines in—*

Triennial Period.	Great Britain. Tons.	Germany. Tons.	United States. Tons.
1905-7	289	248	589
1908-10	265	239	591
1911-13	254	263	651

During the war the British outputs have continued to fall at an alarming rate, until in 1918 they reached the low level of 232 tons per worker employed. In marked contrast to this, the American figures have continued to rise at an accelerated rate until in 1916 they reached 732, and in 1917 the *phenomenal record* of 768, tons per worker employed. The official figures for the total production of coal in American mines in respect of each year since 1913 are given in Table III.

TABLE III.—*Outputs of Coal in the United States during the Period* 1913-17 *inclusive.*

Year.	Total Output. Million Tons.	Output per Worker employed at the Mines.
1913	508 9	681
1914	458·5	601
1915	474·6	647
1916	526·9	732
1917	581·7	768

It would thus appear that in the year 1917 the American output per worker employed was more than three times that realised in British mines.

The figures given in Table IV. show how the wholesale prices of typical classes of American fuels have moved during the war.

TABLE IV.—*Average Wholesale Prices of Coal and Coke per Long Ton in the United States for each Year since* 1913.

	Stove Anthracite at New York. s. d.	Semi-bituminous Pocahontas, f.o.b. Norfolk, Va. s. d.	Bituminous Pittsburg, Run of Mine, f.o.b. Cincinnati. s. d.	Connelsville Coke. s. d.
1914	21 1	12 6	10 3	8 5
1915	21 0	11 10	10 3	8 4
1916	22 9	15 6	12 6	15 2
1917	23 5	22 8	21 5	38 6
1918	27 1	18 8	18 1	28 0

From an examination of the monthly returns it appears that, with the exception of those of anthracite, American wholesale coal and coke prices rose sharply during the *latter half of* 1916, and reached a maximum about the middle of 1917. Thus Pocahontas reached a maximum of 29s. 2d. (f.o.b. Norfolk, Va.) in May-June, 1917, and bituminous one of 28s. per ton (f.o.b. Cincinnati) at the same period. Connelsville coke, which is that used in the Pittsburg blast furnaces, touched a maximum of 57s. 2d. per ton in 1917. After that period prices fell "under control." Thus Pocahontas fell to a minimum of 16s. 3d. in August-October, 1917, since which time they have steadily risen until in April, 1919, they were at 20s. 5d. per ton. Bituminous fell to 14s. in September-October, 1917, but have since risen to 18s. 8d. per ton (f.o.b. Cincinnati) in April, 1919. Connelsville coke kept at 28s. for a period of fifteen months from October, 1917, to December, 1918 (both inclusive), since which it has *steadily declined, month by month, until in April, 1919, it* stood at 18s. 2d. per ton. In the same month the price of Durham coke at the ovens was 33s. per ton *plus* a subsidy (paid by the Government) of 5s. 7d. per ton. It thus appears that already American fuel prices have fallen to a level considerably below those ruling in this country, a circumstance which gives American manufacturers a great initial advantage over our own.

Research on the Chemistry of Coal.

Since the previous report, Prof. Bone has continued to direct the research work upon the Chemistry of Coal at the Imperial College of Science and Technology, London, which he originally undertook in 1916 at the instance of the Committee. In conjunction with Mr. R. J. Sarjant he has recently published, in the *Proceedings of the Royal Society*, the results of a series of experiments upon the so-called solvent action of pyridine upon coal, to which Bedson (*Journ. Soc. Chem. Ind.*, 1908, p. 147) first drew attention in the year 1899. Since that time it has been investigated by a number of other chemists as a possible means of discriminating between the chief types of constituents of the coal substance. Wheeler and his co-workers have employed it extensively in their researches, claiming that if the portion of the coal removed by pyridine be subsequently extracted with chloroform, a complete separation of the resinic from the cellulosic constituents may be effected (Clark and Wheeler, *Trans. Chem. Soc.*, 1913, ciii., p. 1704). On the other hand, the independent work of Harger (*Journ. Soc. Chem. Ind.*, 1914, p. 384), Wahl (*Comptes Rendus*, 1912, cliv., p. 1094), Vignon (*Comptes Rendus*, 1914, clviii., p. 1421), and others raised the question whether the action of pyridine, and other similar basic solvents, is really one of ordinary solution, and much of the evidence obtained by them suggested that it is chiefly a depolymerising one. Prof. Bone's recent experiments support this latter view, and point to the conclusion that the action in question affects the coal substance as a whole, and is by no means confined to any one constituent of it. The action is retarded, in a degree which may vary considerably according to the character of the coal, by the presence either of water in the solvent or of oxygen in the atmosphere in which the extraction is carried out. In order to obtain comparable results with a series of different coals it is, therefore, necessary to operate with a carefully dried solvent, and in an atmosphere from which oxygen is excluded. Suitable means and apparatus have been devised for carrying out extractions under such precautions. It has also been shown that the action of pyridine at its boiling-point (under atmospheric pressure) upon a particular coal approaches in time a practical limit which, however, may be considerably exceeded if the extraction is carried out at higher temperatures (*e.g.*, in sealed tubes under pressure). Prof. Bone and his co-workers have also devised a method for extracting in a pure condition the resinic constituents of coal, particulars of which will shortly be published.

In connection with the question of the organisation of systematic investigations upon the chemical characters of the principal British coal seams, this Committee desires to reiterate the opinion expressed in its First Report, namely, "that the resources, both of existing laboratories which have been established in this country for the special investigation of fuel problems, and of other laboratories where the technique of the subject has been developed, might be utilised more than they are in this connection, and that the time is ripe for the organisation of a scheme of systematic co-operative research aided by national funds in which all such laboratories may participate."

The Committee regrets to say, however, that, notwithstanding the establishment of the Fuel Research Board, with large funds at its disposal, no attempt has apparently yet been made to organise any such comprehensive scheme as was recommended in 1916; and it wishes again to impress upon both the public and the Department of Scientific and Industrial Research the danger of sterilising fuel research by a policy of over-centralisation. On the contrary, it is of the opinion that what is most needed is a broadly-planned policy which will aim at stimulating and assisting experimental work on the chemistry of coal, fuel economy, and cognate subjects, everywhere throughout the whole Kingdom.

(To be continued).

NOTES.

"A Dreadful Fallacy."—There is a dreadful fallacy at present fermenting in the minds of many working men—that the less work they do, the more work will be left for others. That fallacy is one of the things which this country has to conquer. It is doing us more harm than any other erroneous belief with which I am acquainted. Linked with it is another fallacy, that when you nominally receive more money you get better wages. It is said that in Bolshevist Russia the working man gets £100 a week, and cannot buy boots or clothes, because they cost hundreds of pounds. At the present moment we are suffering from the fallacy that money is real, that when you say a pound in 1919 you mean the same thing as you meant when you said a pound in 1914. We all know that this is not so. I have no doubt of the capacity of this country to conquer all the difficulties that lie in its path once it realises what they are. If we set out to conquer those difficulties, as we conquer them we shall find our export trade expanding, and the prosperity of the community developing in a way that few deemed possible during the war or in the years before. But if we fail to summon up that determination we should have small satisfaction in sharing the shortage which would afflict us all. Dark as the outlook may seem to those who are up against individual problems, the field of our trade as a whole—our export trade—is bright with the light of hope if only we will go forward as a nation to occupy that land of promise.—Speech by Sir A. Geddes at Aldwych Club.

Royal Photographic Society of Great Britain.—The Sixty-fourth Annual Exhibition, 1919, will be held for the third consecutive time in the Society's house, 35, Russell Square, W.C. 1, suitable public galleries being still occupied by Government Departments. The Exhibition was opened October 13, and will be open daily from 11 a.m. till 9 p.m. till November 29; the public is invited to view the photographs free of charge, by entering their names and addresses in the signature book. Lantern lectures on popular and interesting subjects will be delivered each Tuesday and Friday evening at 7 p.m. As usual, the exhibits are divided into pictorial, colour (including transparencies), and scientific photographs. A special feature is the collection of photographs of the scenery, population, and industries of the South Pacific Islands, by Mr. T. J. McMahon, who will deliver a series of lectures on Wednesday evenings, in the hope of rousing the English public to the importance, to the British Empire, of trade with these Islands. The Scientific Section is even more than usually interesting by reason of the diversified nature of the exhibits, comprising, as they do, biological, natural history, microscopical, X-ray, botanical, astronomical, and other applications of photography. Experts in each of these sections will find much to rivet their attention, but one exhibit which is likely to appeal to all is the series of photo-micrographs by Major Kaye and Dr. Knox, showing how defects in parts of aeroplanes were detected, although quite invisible externally to ocular examination, and in some cases concealed by the linen wrappings. In one instance a strut had been cut off too short and a false packing piece inserted, in another a wooden block was misshaped and split by the screws, in yet another case extensive beetle borings were discovered in the wood. Had these weaknesses passed unnoticed, brave men's lives would have paid the forfeit. One other exhibit remains to be noticed, and that is a series of graticules, line screen reproductions, micrometers, and other fine scales, &c., in which absolute sharpness of image is of importance. This series is exhibited by Messrs. Julius and Ernest Rheinberg, who worked out the processes by which they are produced in order to provide scales for the many instruments of precision in demand during the war. Now that that demand has been satisfied, there will be ample employment for this new and valuable process in providing micrometer scales, &c., for the use of microscopists, astronomers, and others.

The Eighth Annual General Meeting and Conference of the British Commercial Gas Association will be held at the Central Hall, Westminster, on Tuesday and Wednesday, October 28 and 29, under the presidency of the Rt. Hon. Lord Moulton, F.R.S. The subjects before the Conference will be Fuel Conservation, Housing, and Smoke Abatement Problems. Papers on these subjects will be read by Sir Dugald Clark, F.R.S., Mr. H. Austen Hall, F.R.I.B.A., Prof. Leonard Hill and Dr. H. A. des Vœux, and Dr. C. W. Saleeby.

The Committee appointed by the Board of Trade to consider and report upon non-ferrous mining in the United Kingdom held its first meeting after the recess on October 13, under the Chairmanship of Mr. H. B. Betterton, M.P. It has decided to deal in the first instance with tin-mining, and will proceed forthwith to take evidence. Subsequently, the Committee will take up the question of zinc and lead mining. The Committee again met on October 14, 15, and 16, under the Chairmanship of Mr. H. B. Betterton, M.P., when evidence was given by Mr. C. A. Moreing, M.Inst.C.E. (of the firm of Bewick Moreing and Co.), General Manager of the Tobidy Minerals, Limited, and East Pool and Agar, Limited, and representing the Cornish Chamber of Mines and the Joint Industrial Council of the Tin-mining Industry in the United Kingdom. Mr. Moreing stated that in his opinion the mines on the Redruth and Camborne Line of lodes should be amalgamated and worked on a large scale, a plan which held out the only hope of economic success in the future. He pointed out the real importance of the mining industry of Cornwall, not only to those actually employed in the mines and the population dependent on them, but also to the country at large. Next week the Committee is proceeding to hear further evidence from Cornwall.

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THE CHEMICAL NEWS

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IS THE ELECTRICAL CONDUCTIVITY OF THE ELEMENTS CONDITIONED BY THE PRESENCE OF ISOTOPES?

THEORY OF ELECTRICAL CONDUCTION—NOTES.

By F. H LORING.

1. IN the CHEMICAL NEWS (cxix., p. 14) I discussed the possible influence of isotopes in conditioning the electrical conductivity of elementary substances, particularly pure metals, the treatment being qualitative. In a following note in the same journal (cxix., p. 62) the subject was dealt with quantitatively, and a suggestion was finally made that "the theory of conduction is of possible interest in connection with the apparent atomic relationships shown; for, consider a small-mass nucleus so close to a large-mass nucleus that the electronic orbits combine (or nearly combine) to form a figure-eight, the electrons tending to leave the former to pass round the latter owing to the greater attraction of the larger mass. Overloading the circuit electrically at any point might then give rise to a progressive flow of electrons from atom to atom. On cooling the metal, a point might be reached when further cooling (contraction) would not improve the contiguity of the orbits, so that perfect conductivity of electricity without any oscillation or vibration of the atoms (heat or C²R loss) might take place at a temperature just above the absolute zero."

2. Inasmuch as most of the statements in the literature on the subject of conduction in metals implicity indicate that this property arises from the freedom accorded to gas-like electrons in flowing through the inter-atomic spaces, I think that Sir Oliver Lodge's statement in "Electrons," p. 107, should be noted in connection with the foregoing one. "The fire-bucket method must be the method of conduction in solids, where the atoms are not susceptible of locomotion and can only pass electrons on from hand to hand, oscillating a little to deliver them up, and so getting thrown gradually into a state of vibration which we call heat. But it may be observed that this need for motion, in order to pass electrons on, becomes less according as the body is less subject to the irregular disturbance we call heat. It may be that the expansion and molecular separation [physicists sometimes use the term *molecule* in a broad sense when not wishing to distinguish specifically between the atom alone and its combination in more or less distinct groups], or it may be the irregular jostling and disturbance that impede easy conduction; but certainly conduction improves as temperature falls and transmission becomes quite easy at very low temperatures" (see also pp. 108—109).

3. That interest is manifest in the question under discussion may be gathered from the query raised by Prof. R. A. Fessenden in *Nature* (August 28, 1919, p. 505), in which the following appears:—"If the cohesion depends on electrons in the outer rings, the tensile strength of the lead isotopes should be the same; but might not their electrical resistance and sound velocities (easily determined for small quantities of material by resonance methods) afford a means of distinguishing them?"

4. The physical and chemical states of matter play such a profound part in respect of the facility with which electrons can move from atom to atom, that the isotopic percentage theory suggested, is thereby subject to further considerations or amendments, since probably no complete theory can be evolved without taking into account chemical affinity.

5. The inclusion of such elements as bromine and iodine in the series shown (CHEMICAL NEWS, cxix., p. 62) was not justified without referring to the molecular state of these elements; but notwithstanding this restriction, their theoretically very high percentage of higher mass isotopes coincides with their exceedingly high resistivity—very much as zero chemical affinity coincides with zero valency in the case of the inert gases, to take an analogous example. It is of interest to bear in mind that some molecular compounds are appreciably conducting, as, for example, cuprous iodide, which is supposed to conduct electronically rather than through the agency of ions (see K. Baedeker, *Phys. Zeit.*, 1912, xiii., p. 1080; *Sci. Abs.*, A, 1913, p. 217). Whether the theory here given for metallic conduction will prove of interest in connection with the ionic theory is a matter for future consideration.

6. It would appear from the relation shown that maximum conductivity occurs when the percentage of higher-mass isotopes is about 25. Silver is theoretically 22·2. Should a large square be divided into 100 small squares and 25 per cent of these be equally disposed amongst the remaining squares which represent atoms of relatively lower mass, a condition of maximum uni-directional conductivity in one plane may thus be represented, each larger-mass atom being completely surrounded with those of smaller mass. Upon increasing the number to 50 per cent, *i.e.*, making the two atomic species equal in number, the uniform disposition would be apparently such that the conductivity could only be improved by supposing the metal to accommodate two currents, each flowing simultaneously in opposite directions—which seems impossible (see J. Koenigsberger and G. Gottstein, *Phys.*, *Zeit.*, 1913, xiv., p. 232; *Sci. Abs.*, A, 1913, p. 390).

7. These peculiarities, attributed in part to isotopic proportions, may help to elucidate the Hall effect and those effects allied thereto, which are so complex that up to the present no satisfactory electronic theory has been formulated. The Hall effect reaches a very high value with bismuth, which element has theoretically an equal number of different mass isotopes; but as tin and lead theoretically have nearly balanced isotopic proportions it might be expected that these two elements would exhibit large magnitude effects, whereas they do not. The tin coefficient is comparable with that of copper—the roughly parallel series being—

(*a*) Cu, Ag, Zn . . .

(*b*) Sn, Pb, Sb, Bi, Te.

(See O. W. Richardson, "Electron Theory of Matter," pp. 434—440). The diagram (CHEMICAL NEWS, cxix., p. 63) is, however, suggestive in this connection.

8. It will be seen that by increasing the proportionate number of larger-mass isotopes much beyond 50 per cent, the conditions should be such as probably to interfere with the continuity of action suggested by the theory, and also some molecular-like condition may set in which causes a sort of pseudo-isotopic state as tentatively suggested with regard to alloys (see 5). On the other hand, a decrease of larger-mass isotopes below 25 per cent would seemingly produce a similar increase in resistivity unless some other physical or molecular-like condition further modifies the conductivity, as may be the case with copper, the theoretical percentage of which is 12·5.

9. In specifying the factors entering into metallic conduction the following are those experimentally indicated:—

Heat.
Isotopic proportion or percentage?
Chemical affinity or atomic association.
Crystalline structure and heat treatments.
Purity and mechanical work-up.

There appears to be no case or record in which the resistance of an alloy is less than any one of its low resistance constituents, and similarly impurities always lower the conductivity.

10. This theory is of possible interest in connection with the photo-electric effect, for if the electrons in metals are

in orbital movement, then at the surface of the metal there are open orbits (exposed orbits), and if light of short wave-length is capable of expanding these orbits (those favourably disposed), just as heat waves are absorbed and expand metal in bulk, the electrons should fly out of the metal very much as molecules leave a liquid on evaporation. Postulating atoms of different mass, ununited chemically in the orthodox sense, all mixed up together, means that there should be instability in the electronic orbits, and it is this instability that might give rise to easy conduction and other effects requiring only a small starting force to give rise to certain phenomena. See D. Owen, "Recent Physical Research," 1913, for an impartial discussion of some of the foregoing subjects.

Dr. Owen, in referring to the number of electrons in unit volume of metal (p. 140), says:—"It will be seen below that the estimates are by no means in perfect agreement. One is forced to conclude that in spite of its alluring simplicity the free electron theory should be held for the present with much reserve." I think that these relations under discussion give support to this contention.

11. In considering the possibility of separating isotopes, it must be remembered that they are so thoroughly mixed owing to diffusion that to overcome diffusion, which is a force, is not an easy problem.

12. The fact that, for example, bromine atoms strongly unite (Br_2), the theoretical difference in the atomic weights of the supposed isotopic atoms being smaller than in the metals under consideration, or the difference being less compared with the whole mass, seems to suggest that chemical affinity reaches a maximum in elements of this class, so that the difference in this respect must be sought in the mutual adaptability or co-ordination of the nuclei and the external electrons. Such elements might afford a better chance for a combined effect than would be the case when the relative masses are somewhat greater, but as the difference increases relative to the whole mass, maxima and minima forces probably come into play; that is to say, the effect is periodic.

Pure metals and the inert gases crystallise, which indicate the presence of a directive force. There are therefore forces which might be summarised thus:—

1. Chemical, as in the formation of molecules.
2. Cohesion, as in the metals or amongst molecules.
3. Directive, as in the formation of crystals.
4. Diffusion; as in liquids and gases.

The complexity of matter will be seen, even should all the forces have one common origin; and these complexities should be taken into account in the study of electrical conductivity (see Chemical News, 1918, cxvii., p. 319).

13. There is one point in connection with valency which may be a means of elucidating one phase of the phenomenon, and that is that when atoms or molecules become closely packed the force of affinity is more or less freed from co-partnership, so to speak, and the force becomes partly released so that it can spread out radially from the atoms or molecules, and thereby exercise wide or diffuse influence. X-ray analysis of crystals seems to point to this sort of effect. Pure copper crystals are, of course, known, and X-ray analysis reveals a simple arrangement of the atoms (W. L. Bragg, *Phil. Mag.*, xxviii., p. 355). It is therefore deducible that even in metals affinities exist, as in purely chemical compounds, and probably this effect and diffusion are in a sense only two aspects of the same general phenomenon.

The Secretary of the Department of Scientific and Industrial Research announces that the following Research Associations have been formed in accordance with the Government Scheme for the Encouragement of Industrial Research:—British Rubber and Tyre Manufacturers' Research Association (care of Messrs. W. B. Peat and Co., 11, Ironmonger Lane, E.C. 2); The Linen Industry Research Association (Secretary, Miss M. K. E. Allen, 3, Bedford Street, Belfast).

THE LIBRARY OF THE CHEMICAL SOCIETY.

A Record of a Recent Attempt at Co-operation.

By F. W. CLIFFORD.

In view of the interest which has arisen in the technical applications of chemistry and in libraries which would provide facilities for the consultation of books on more technical branches of science, a development of the Library of the Chemical Society, assisted by other kindred societies, has been in progress for the last two years. This scheme, initiated by the Chemical Society, is now effected, and an account of the arrangements which have been made for carrying it out may not be without interest to readers of the *Library Association Record*.

The activities of the war caused a considerable demand upon the resources of all libraries of a technical character, and that of the Chemical Society was frequently called upon by the War Office and other Government Departments for works which could not be found elsewhere. Luckily for the nation, the policy of the Council towards the library has always been of a generous nature. The systematic consideration of new books, and their purchase by the Committee irrespective of demand, had resulted in a collection of volumes, not only containing all books dealing with the scientific side of chemistry which were of any real value and importance, but also books on applied chemistry when these dealt with the chemistry of the processes involved. Consequently, important works of foreign origin were to be found upon the library shelves, and were of the greatest possible value to the various War Departments and to manufacturers who were striving to make essential products hitherto made in what had become an enemy country.

The Library Committee, on inquiry into this increased use of the library, came to the conclusion that the demand was likely to be of a permanent character, and that the time had arrived for the extension of the Society's library in the more technical direction. They were also of the opinion that if the Chemical Society were to place the existing library and proposed extension at the service of members of such other societies and associations as might wish to co-operate, it was probable that they would be glad to have the opportunity of relieving themselves of the necessity of collecting and maintaining the literature of their special subjects, whilst at the same time they would assist in the formation of a representative library of chemical literature such as would be difficult to obtain by individual effort. It was also hoped that the project of co-operation in the use of one central library of chemical literature might assist in no small measure in promoting a closer relationship between the several societies dealing with the various aspects of chemical science.

The Report formulated by the Library Committee was duly adopted by the Council of the Chemical Society, who decided to proceed immediately with the proposed extension of the library and to call a conference of representatives of societies and associations connected with chemical science and industry to discuss the question of co-operation. This conference was held in October, 1917, when the Chairman of the Library Committee described the aims and objects which the Chemical Society had in view in proposing the scheme.

The representatives expressed a very cordial approval of the proposal, and after a further conference held in March, 1918, a number of the societies represented intimated their desire to co-operate, and offered financial assistance. It is of interest to note that one of the contributing societies subsequently held a general discussion at which the principles of co-operation were referred to. A comment upon that meeting by Mr. Savage appeared in the *Library Association Record*, 1918, xx., pp. 219—222.

In order that the library would be of the greatest value, it was considered necessary to extend the hours of opening, and a provisional scheme was commenced in January, 1919, with extended opening on three days weekly. The

full proposal was carried out on May 1, and the library is now open daily from 10 a.m. to 9 p.m., with the exception of Saturdays when it is closed at 5 p.m.

The following societies, &c., have co-operated in the extension, giving financial support to the scheme, and their members have now full use of the library, both for loan and reference:—Association of British Chemical Manufacturers, Biochemical Society, Faraday Society, Institute of Chemistry, Society of Chemical Industry, Society of Dyers and Colourists, Society of Public Analysts.

The Library Committee is composed of six Fellows of the Chemical Society, the Honorary Officers, the Editor, and the Librarian, together with seven representatives from the contributing societies. The present Chairman of the Committee is Prof. J. M. Thomson, LL.D., F.R.S., whose sympathy with, and continuous interest in the scheme, has done so much to bring it to a successful issue.

The arrangements outlined in this brief sketch cannot but be of the greatest value to chemical science, and it will be a matter for further congratulation if the initiation by the Chemical Society of co-operation in the direction described may in the future lead to still more important results. So long as such a co-operation remains no chemist can ever plead that he is unable to obtain access to the specialised library dealing with the literature of his profession.—*Library Association Record*, August, 1919.

URANIUM AS AN INDUSTRIAL POISON.

Certain toxicologic effects of salts of uranium have long been recognised and applied in the study of experimental physiology and pathology. Recently industrial conditions have arisen which may place this element in the class of possible dangers of occupation. Karsner and his collaborators of the Western Reserve University School of Medicine, Cleveland, have asserted that in certain industries uranium is employed or appears as a by-product, and that with war time scarcity of some other heavy metals, such as tungsten, uranium may be utilised as a partial substitute. (H. T. Karsner and S. P. Reimann, "Studies of Uranium Poisoning, I. The Toxicity of certain Water-Insoluble Salts of Uranium," *Journ. Med. Res.*, Nov., 1918, xxxix., 157. H. T. Karsner, S. P. Reimann, and S. C. Brooks, "Studies of Uranium Poisoning, II. The Solubility of Uranium Oxide in Artificial and Human Gastric Juice," *Ibid.*, Nov., 1918, xxxix., 163, 169, 177). In the production of radium, uranium oxide is produced in large quantities, and if uranium were employed in the steel industry the high temperatures used would lead to the formation of one or several oxides, the most important being uranium dioxide and uranous uranate, both of which are insoluble in water. In grinding, polishing, and perhaps in other operations, these oxides might appear in the form of a dust.

Animal experiments conducted by the Cleveland pathologists demonstrate that uranium oxide, the state in which the metal is most likely to reach the upper respiratory tract when distributed industrially in the form of dust, can be toxic and fatal when administered by mouth. This oxide is insoluble in water; but it will dissolve in gastric juice, so that the possibility of the formation of a soluble toxic salt is established. The production of nephritis by uranium salts has long been recognised as an experimental fact, and the method has served to facilitate the study of the pathology of renal functions. Karsner and his associates have observed that the excretion of uranium, so far as it is accomplished, is primarily by way of the kidneys. When functional and anatomic lesions arise in the kidneys through the presence of the poison, the decreased effectiveness of excretion makes matters worse by favouring an accumulation of the metal in the kidney. There is, probably, no special "affinity" of uranium for the kidney cells nor any unusual susceptibility to the poison on their part. The possibility of protecting the kidneys by the administration of alkalies to combat the concomitant acidosis in such cases represents one of the therapeutic considerations that experimental medicine has taught. (W. deB. MacNider, "The Inhibition of the Toxicity of Uranium Nitrate by Sodium Carbonate," *Journ. Exper. Med.*, Feb., 1916, xxiii., 171; "Relative Toxicity of Uranium Nitrate," *Journ. Exper. Med.*, July, 1917, xxvi., 1, 19).

Incidentally it should be stated that uranium nitrate was admitted to the Ninth (the most recent) Revision of the U.S. Pharmacopœia. Surely the danger of this salt could not have been appreciated when this action was taken by the Revision Committee. There does not apper to be sufficient evidence of its therapeutic value to warrant inclusion in this official book. The drug is not included in the Useful Drugs, prepared by the Council on Pharmacy and Chemistry. The Epitome of the U.S. Pharmacopœia, prepared for the use of physicians by a special committee of the Council on Pharmacy and Chemistry, has this to say under "Actions and Uses"—"(Uranium nitrate) . . . has been used, without adequate justification, in the treatment of diabetes and cancer. Solutions are poisonous and produce glucosuria when injected subcutaneously, even in small doses." Our previous knowledge of this drug, now adequately supported by the work of Karsner, should lead the next Revision Committee to omit the drug from the Pharmacopœia.—*Journal of the American Medical Association*, June 28, 1919.

FUEL ECONOMY.*

(Concluded from p. 198).

Fuel Consumptions in the Iron and Steel and other Industries.

During 1916 the Committee circulated a series of carefully drawn questions among selected representative iron and steel works in Cleveland, Lincolnshire, Sheffield, and the Midlands generally, with a view to collecting reliable data concerning the then fuel consumptions in blast furnaces, steelworks, and rolling mills. This information has since been analysed and embodied in a Report which, by arrangement with the Council of the Iron and Steel Institute, is to form the basis of a full day's discussion on the question of fuel economy at their forthcoming Autumn Meeting in London on September 18 next. It will subsequently be published *in extenso* in their Journal, and thus be made available to the industry at an early date. On the same occasion also, a valuable Memorandum, written for the Committee by Mr. H. James Yates, on "Fuel Economy in Cupola Practice," will be presented and discussed. The Committee is thus actively co-operating with the Iron and Steel Institute in promoting fuel economy in iron and steel works.

The Committee has also been in touch with the Federation of British Industries with regard to the setting up of an organisation for promoting fuel economy in industrial establishments generally, and for helping manufacturers by expert guidance on matters connected with the use of coal. The question was referred to a special Committee of the Federation, who reported to its Executive that it is in the province of the Federation to initiate a scheme, which it hopes shortly to do.

Electric Power Supply.

The Committee has had under consideration the recent Reports of various Government Committees upon the question of the reorganisation of Public Electric Power Supplies in Great Britain, which is now engaging the attention of Parliament. Whilst recognising the need of such reorganisation, and generally approving (a) of the proposed division of the country into areas in which the

* Second Report of the Committee. Read before the British Association (Section B), Bournemouth Meeting, 1919.

authorities dealing with the generation and main distribution of electricity shall be co-ordinated, and (*b*) of standardising in each of such areas the frequency and voltage of the main transmission and distribution system, the Committee desires to reserve any expression of opinion as to the best means of carrying out the needed reform until the Electricity Commissioners have been appointed and their specific recommendations for the various areas have been published.

Future Standards of Public Gas Supplies.

The Committee has had under consideration the Report issued on January 29, 1919 (Parliamentary Paper, Cmd. 108) by the Fuel Research Board in reply to the inquiry of the Board of Trade as to "What is the most suitable composition and quality of gas and the minimum pressure at which it should be generally supplied, having regard to the desirability of economy in the use of coal, the adequate recovery of by-products, and the purposes for which gas is now used."

Recognising that the said Report opened up important and far-reaching questions of public policy with regard to the manufacture and distribution of town's gas, the Executive, after receiving separate Memoranda on the subject from Prof. Bone and Mr. E. V. Evans, referred the whole matter for detailed consideration to a Sub-Committee consisting of Sir Robert Hadfield, Prof. Bone, Dr. E. Stead, Messrs. A. H. Barker, E. Bury, E. V. Evans, D. H. Helps, D. V. Hollingworth, A. Hutchinson, R. Mond, W. H. Patchell, and H. James Yates.

This Sub-Committee having reported that it had arrived, by an eight to one majority, at the conclusions embodied in the following numbered paragraphs, they were formally adopted by the Committee as a whole, and ordered to be incorporated in the Report as the findings of the Committee on the subject.

1. The chief recommendations made by the Fuel Research Board embody substantially the following propositions:—

(*a*) That the consumer shall in future be charged according to the thermal units in the gas actually received by him, just as a consumer of electricity is charged for the Board of Trade units which have passed through his meter.

(*b*) That, subject to a maximum limit of 12 per cent of inert constituents, and of its undertaking to adjust consumers' lighting, heating, and cooking appliances so that the gas can be burnt in them with both safety and efficiency, the gas undertaking shall be at liberty to fix the calorific value of the gas it supplies to its customers, although in the common interests of producers and consumers it is suggested that burners shall be standardised for a limited number of calorific values of gas of which (it is suggested) four grades may be sufficient, namely, 400, 433, 466, and 500 B.T.U. per cubic foot.

(*c*) That every supply district above a certain magnitude ought to be provided with one or more gas examiners and, if necessary, a staff of inspectors, whose whole time should be devoted to looking after the interests of gas consumers, and that the smaller supply centres should be grouped into districts for such purposes.

(*d*) That, provided customers' appliances are properly adjusted to the grade of gas supplied, it may be tentatively accepted that the relative values of different grades of gas are strictly proportional to their calorific values. Thus, for example, the "relative values to the consumer of gases of 500 and 400 B.T.U. could be taken as exactly in that ratio."

(*e*) That there shall be more complete removal of sulphur and cyanogen compounds from the gas.

(*f*) That, under normal conditions of supply and equipment, there shall be a pressure of not less than two inches of water in the gas at the exit of the consumer's meter.

2. With regard to these recommendations, the Committee generally agrees that, provided (*a*) that simple and effective means or apparatus could be devised, and put in general operation, for determining the heat units actually received by each individual gas consumer throughout the Kingdom, and (*b*) that certain other conditions (hereinafter set forth) were assured, it would be more equitable to charge the consumer on a basis of "heat units" than on one of "cubic feet" supplied.

3. The Committee also agrees generally with the Fuel Research Board's recommendations as to (*a*) the maximum limit of 12 per cent of inert constituents, and (*b*) the minimum pressure of 2 inches of water in the gas at the exit of the consumer's meter.

4. The Committee considers that it should be the aim of any national policy in regard to gas standards to ensure (*a*) to the consumer, and especially to the domestic consumer, a supply of gas suitable to his requirements at the lowest cost consistent with reasonable safety, and (*b*) to the community at large, as great a recovery of valuable by-products in the carbonising process as is consistent with the production of a reasonably safe and usable gas. It certainly out not to exclude the possibility of (*a*) distributing through the public mains surplus coke-oven gas, or (*b*) securing, to a safe and reasonable degree, the advantages in regard to reduced costs of production accruing from the modern practice of steaming the incandescent coke produced by carbonising coal in vertical retorts on the continuous system. It by no means necessarily follows, however, that a gas undertaking ought to convert all its coke into water gas, as some of them apparently would like to do. It might conceivably be better policy to require gas undertakings, or at least some of them, to produce and supply the community with (*a*) a straight coal gas obtained simply by carbonising the coal, and (*b*) a free-burning coke, or semi-coke, fit for consumption in domestic grates.

5. From information supplied to the Committee it would appear that, with regard to the quality of the gas generally supplied to consumers in days immediately preceding the war, the following figures may be quoted for the average gross calorific values, per cubic foot at 60° Fahr. and 30 in. barometer, of the gas supplied during the year 1913 in six of the largest cities of Great Britain:—

620, 596, 593, 582, 580, and 540 B.T.U.

While it may be freely admitted that calorific value, although always an important one, is by no means the only factor to be considered in selecting a gaseous fuel for any particular purpose, the Committee is of the opinion that the proposal of the Fuel Research Board that in future gas undertakings may be allowed to supply, at their sole discretion, gas of any calorific value between 400 and 500 B.T.U., ought to be very carefully scrutinised in all its bearings, especially as it involves a considerable dilution of the old "coal gas" by "water gas," with consequent much higher carbonic oxide and lower methane contents. Indeed the Fuel Research Board holds that "the natural diluent for coal gas is water gas, made either from coke in a separate producer, or in retorts by steaming the hot coke."

6. The composition of the gas obtainable by carbonising British gas coals at high temperatures either in modern vertical retorts or coke-ovens, without steaming the charge, usually varies between the following limits, approximately:—

	Per cent.	Approximate mean.
CO_2	2—3	2·5
CO	5—10	7·5
C_nH_m	2—4	3·0
CH_4	25—35	30·0
H_2	45—55	50·0
N_2	5—10	7·0

The calorific value of a gas of the mean composition indicated would be about 560 gross and 495 net B.T.U.

per cubic foot at 60° F. and 30 in. barometer. The corresponding values for a "debenzolised" coke-oven gas, containing only 25 per cent of methane, would be about 485 gross and 425 net. And inasmuch as the thermal efficiency of such carbonisation processes is admittedly high (see Note), there would appear to be no particular reason, on the ground merely of thermal efficiency, for seeking to supersede the 1913 practice. The plea for the change is presumably based on the desire, on the part of gas undertakings, to convert a substantial part (or possibly the whole) of the coke into water gas, and thus to increase the gas-make per ton of coal at a corresponding sacrifice of the coke-yield.

(NOTE.—It has recently been shown that the two Metropolitan Gas Companies in the year 1913 actually sent out in the form of gas, coke, and tar rather more than 70 per cent of the potential energy of the coal carbonised, and that over-all efficiencies exceeding 82 per cent have been attained in large-scale carbonising tests).

7. Water gas may be generated from coke with a thermal efficiency of (up to) 70 per cent; it contains on an average:—

CO_2	4·5	per cent.
CO	43·0	,,
H_2	48·0	,,
CH_4	0·5	,,
N_2	4·0	,,

Its calorific values per cubic foot at 60° F. and 30 in. barometer are approximately 300 B.T.U. gross and 275 net, or rather more than half those of the "straight" coal gas already referred to. Its calorific intensity, however, is distinctly higher, but its range of inflammability with air considerably wider, than that of coal gas. Its high carbonic oxide content makes it a poisonous gas, and, owing to its high hydrogen and low methane contents, its mixtures with air are very liable to back-fire. For these reasons it is not a desirable gas for domestic uses unless largely diluted; and any large admixture of it with coal gas in public supplies would undoubtedly add materially to the dangers of carbonic oxide poisoning and of gas explosions in houses.

8. With regard to the question of the dangers of carbonic oxide poisoning with a gas containing a large proportion of water gas, it may be recalled that twenty years ago this was the subject of an official Inquiry by a Committee appointed by the Home Office, of which Dr. J. S. Haldane and the late Sir William Ramsay were members. They had laid before them detailed information as to the Uses of Water Gas in the United States and its effect upon Human Health. In their report (C. 9164 of 1899) they stated:—

"The most direct, and, in our opinion, the only effective method of preventing danger from water gas is to fix a limit which the carbonic oxide in a public and domestic gas supply shall not, in ordinary circumstances, exceed. It is difficult to assign a limit applicable to all circumstances. In some cases 12 per cent of carbonic oxide in the gas supply might be proper, in others 16, or perhaps 20. . . . We are of opinion that with the present conditions of gas supply 20 per cent is the highest proportion of carbonic oxide that should be allowed, and that this percentage should be used only under special circumstances. . . . Our attention has been called by several witnesses to the very imperfect and unsatisfactory gas-fittings often used in the poorer class of houses in large towns, and the constant leakages which exist without any attempt to discover or rectify them. . . ."

Clearly, then, the 1899 Committee, having in mind the nature of carbonic oxide poisoning and the faulty character of gas pipes and fittings in the poorer class of houses, considered that the carbonic oxide content of a public gas supply should in no circumstances be allowed to exceed 20 per cent, and only exceptionally 16 per cent. This Committee considers that even to-day a maximun limit of 20 per cent of carbonic oxide ought not to be exceeded. It may be pointed out that the Fuel Research Board's recommendations would allow of a gas company distributing a 40 per cent coal gas *plus* 60 per cent water gas mixture containing between 27·5 and 30·0 per cent of carbonic oxide.

9. The Committee is unable to agree with the Fuel Research Board's apparent endorsement of the proposition that the relative values of different grades of gases are strictly proportional to their calorific values. On the contrary, they are of the opinion that the chemical composition of the gas is not a matter of indifference to the consumer, and that the cumulative results of forty years of scientific research on the subject prove that the fundamental properties of the explosive mixtures formed by different combustible gases with air, arising from their own peculiar chemical characters and modes of combustion, do affect profoundly their uses for power and heating purposes.

10. It appears to the Committee that, in particular, the Board's Report does not recognise sufficiently the importance of methane as a constituent of a public gas supply. Owing to the relatively narrow range of explosibility of its mixtures with air, and the low speeds at which flame is propagated through them, methane (in addition to the advantages of its high concentration of potential heat units) as a constituent has an important "steadying" influence upon coal gas, rendering it eminently usable for domestic purposes. Hitherto the public has been accustomed to using a gas containing 30 per cent or more of methane, and it is important that such proportions shall not be unduly diminished. Accordingly the Committee would urge the adoption of 20 per cent as a minimum methane content in a public gas supply intended for domestic consumption.

11. If the Committee's proposals in the preceding paragraphs be adopted as safe and reasonable in the interests of domestic consumers, the gas might be sold (as proposed by the Board) on a thermal basis, subject to the following provisos:—

(*a*) That its methane content shall not be less than 20 per cent, its carbonic oxide content not more than 20 per cent, and its content of "inerts" not more than 12 per cent;

(*b*) That its gross calorific value per cubic foot at 60° F. and 30 in. barometer shall not fall below 450 B.T.U.

Within such limits a gas undertaking would be at liberty to supply for domestic use either (*a*) "straight" coal gas; (*b*) "debenzolised" coke-oven gas, or (*c*) a mixture of 100 parts of coal gas with (up to) 50 parts of blue water gas. Where, however, gas is supplied in bulk for industrial uses only, a relaxation in the above conditions might be permitted subject to agreement as regards cost between gas undertakings and the consumers.

12. In conclusion, the Committee hopes that scientific men generally will strongly support the important recommendations made in paragraph 53 of the Board's Report in regard to sulphur purification. The Board rightly urges "the more complete removal not only of the sulphur compounds but also of the cyanogen compounds." The important investigations carried out, from 1906 onwards, at the South Metropolitan Gas Works by Dr. Charles Carpenter, in conjunction with Messrs. E. V. Evans and Doig Gibb, resulting as they did in a process whereby the sulphur content of the gas sent out from these works has been reduced from 40 to about 8 grains per 100 cubic feet, constitute so notable an advance in the technology of gas purification that the time has surely come for legislative action in the direction of making such sulphur removal generally compulsory for all large gas undertakings.

Mr. D. H. Helps, representing the Institution of Gas Engineers on the Committee, dissented from certain of the foregoing conclusions on the grounds that if in future the consumer is charged for gas according to the number of

heat units supplied to him in it, it will not be necessary to impose upon gas undertakings the restrictions in regard to inert constituents which the Committee has recommended. He was also opposed to the suggested limitation in regard to the carbonic oxide content, as well as to any re-imposition of the obligation upon gas undertakings to remove sulphur impurities other than sulphuretted hydrogen from the gas; and in regard to the question of pressure he was of opinion that a minimum of 1½-inch water gauge would be found sufficient.

During the discussions which took place upon the question of gas standards, the attention of the Committee was called to what is known as the "stripping of coal gas," by which is meant the extraction of benzenoid hydrocarbons from it. This process has been instituted as a war measure in view of the necessity for providing sufficient raw material for the manufacture of high explosives.

It was pointed out to the Committee, however, that with gas selling at its present average price it would probably be of greater financial advantage to the gas undertaking to allow the benzenoid hydrocarbons to remain in the gas if the sale of gas on the proposed new thermal basis is instituted. Though fully realising the present national shortage of motor spirit, the Committee felt that gas undertakings should be under no obligation to remove benzenoid hydrocarbons unless the selling price of motor spirit would justify their doing so on financial grounds.

The Committee recommends that it be reappointed to continue its investigations, with a grant of £25.

THE

USE OF ELECTRICITY IN AGRICULTURE.*

With Special Reference to its Development in Germany.

By JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

(Continued from p. 195).

Electric Lighting.

Electricity for lighting purposes may be produced in a private plant on the farm, or may be taken from a central station. In the former case direct-current is frequently used, while 3-phase current is almost invariably distributed from central stations. The following remarks regarding lighting installations apply equally in both cases.

When electric lighting is employed in agricultural work in Germany the incandescent lamp is generally preferred. It may, in fact, be said that before the war there had been a great decline in the use, and consequently in the manufacture, of arc lamps of all types in Germany, with a corresponding increase in the manufacture of incandescent lamps.

For agricultural purposes many advantages were claimed for the incandescent electric lamp. The light being produced by the glow of a carbon or metal filament in a vacuum within a glass bulb, there is an entire absence of combustion and of flame such as would be incidental to matches, tinder boxes, oil, gas, &c. There is, therefore, no danger from fire, particularly since on the breakage of the glass bulb the filament is immediately destroyed, and the destruction of the filament interrupts the electric current.

Electric lamps should not, however, be placed in contact with very inflammable material, because under certain circumstances the cooling of the bulb by air currents may be interfered with, and the inflammable material set on fire.

The great security against fire with incandescent electric lamps and the powerful lights that can be installed enable the farmer to carry on work in the farm buildings during the dark hours that would not be possible with other lighting systems. Work can be carried out during the morning and evening hours of the autumn, winter, and spring in barns, forage lofts, and similar places where danger of fire ordinarily exists.

Owing to the absence of actual combustion oxygen is not abstracted from the air by the incandescent lamp, and living rooms are not contaminated by the production of impure gases.

The lamps are convenient to instal, and may be placed in any position to suit the lighting effect required, while the lights can be put on or off instantly by the closing or opening of a switch.

Control switches may be placed at an easily accessible point, and generally without reference to the position of the lamps, controlling them singly or in clusters as may be desired. Switches may, for instance, be fixed outside a stable to control the interior lighting, and enable the stable to be examined before entry, or a switch can be installed at one end of a shed by which the shed can be lit up on entry, a further switch at the other end serving to extinguish the lights on leaving.

A species of control much appreciated by farmers, and only possible with electric lighting, is the control of large farmyard lights by an auxiliary switch in the farmer's bedroom, which enables the yard to be conveniently lighted up should a suspicious noise be heard during the night.

The introduction of the metal filament lamp, which only consumes for a given candle-power about one-third of the electricity taken by the carbon filament, renders electric lighting one of the cheapest, if not the cheapest form of lighting.

The half-watt lamp, which gives a light of a colour resembling daylight, and consumes still less current than the metallic filament lamp, but which is at present available only in the larger sizes, enables further economies to be effected, and in the larger powers is much used for outside lighting.

For farm work the following sizes of lamp are generally recommended:—

	Candle-power of lamps.
For living rooms	16 to 25
For bedrooms, engines, cattle-sheds, and passages	16
For barns and hay-lofts	32
For visitors' rooms, yard lighting, and road lighting	32, 50, and more

Lamps in living rooms, bedrooms, and business offices are usually provided with reflectors of glass, metal, or other suitable material for the sake of appearance, and to enhance the lighting effect. In the open air and in working places, such as cattle-sheds, barns, &c., lamps are usually protected by being enclosed in strong glass covers to prevent damage to the holders and lamps from moisture, gases, &c., and where mechanical damage is possible metallic protecting guards are also provided. For installations inside buildings, insulated copper wires are usually employed, which are laid direct on porcelain insulators in cattle sheds of sufficient height to avoid direct damage, in conduit on any of the well known patent steel tube systems, or in ordinary steel conduit.

When it is important to lay the wires inconspicuously, as for the lighting of living rooms, insulated wires covered with a special metallic coating, as in the well known Kuhlo system, are frequently found. The whole lighting system is, as is usual in such cases, protected from unsafe overloading by the provision of suitable fuses. Fuses of the cartridge type, the special feature of which is the un-interchangeable character of the cartridge which prevents cartridges of larger size than is desirable being used on a gven circuit, thus rendering the protection imaginary, are much more common in Germany than in this country.

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Special attention also is given in Germany to the design and manufacture of lighting accessories, such as fittings, fuses, switches, &c., to meet agricultural conditions, and it is interesting to note that similar attention has been devoted in America to the same question, special catalogues being issued by the larger firms.

It is generally urged against electric lighting, and equally also against gas lighting, by farmers that the lamps are not in independent units, as is the case with paraffin lamps and with candles, but have to be connected by wires to an electric circuit. This is undoubtedly a drawback in some cases, but it has the advantage that since the lamps require no attention they may be placed in almost inaccessible places and switched on and off from accessible positions. The difficulty is also, to a large extent, overcome by the provision of portable and temporary lamps which can be connected by means of a flexible cable and plug to a suitably placed wall socket. These lamps may be used in any place provided a wall socket connected to the terminal wiring is available in the neighbourhood.

Portable hand lamps give excellent service to the farmer when repairing wagons or farm implements, or in the stalls, stables, &c., should animals fall ill. Temporary lights carried on suitable supports are also frequently attached to the portable transformer and motor wagons described later.

It may be of interest to note that the average cost of a number of lighting installations on farms put down by one of the largest German companies varied from 14 to 20 marks per point for lamps with simple switches and without electroller, and from 16 to 23 marks with suitable electroller for dry living rooms, halls, &c., while the cost per lighting point in cattle sheds, outhouses, or the open air with waterproof electrollers, was from 21 to 28 marks.

A common figure to take in Germany for working purposes for the cost of electricity for lighting in rural districts before the war was 40 pfgs. per unit. Metallic filament lamps were taken at 2 marks each, and when working out comparisons with oil or candle lighting the life of incandescent lamps was taken at 1000 hours, and thus 0·2 pfg. per hour added to the cost of current for lighting covered interest and depreciation on the lamp.

Lighting by candle was considered to be the most expensive form of lighting, and was taken at $1\frac{1}{2}$ pfgs. per candle-power hour. Lighting by petroleum lamp was considered essentially cheaper and better, and was assumed to cost 0·11 pfg. per candle-power hour with a 20 candle-power lamp, and petroleum at 20 pfgs. per litre.

With electricity at 40 pfgs. a unit, a 16 candle-power carbon filament lamp cost 2 pfgs. for one hour, while a metallic filament lamp of the same candle-power only cost $\frac{3}{4}$ pfg., other candle-powers in both cases being pro rata.

It will be seen on the basis of the figures taken that for equal lighting effect carbon filament lamps are more expensive than paraffin lamps, while metallic filament lamps are much cheaper. Generally speaking, and still assuming the cost of current and petroleum mentioned above, for equal candle-power the running cost of the metallic filament electric lamp is less than half that of the paraffin lamp, and this is additional to the advantages they possess as regard cleanliness, security against fire, continual readiness for use, and illumination better distributed over the work to be done.

The following figures for lighting provided by the proprietors of a few German firms may be of interest. In the case of a farm of about 92 acres, eleven incandescent lamps were installed in the dwelling-house and eleven in the working places, and the cost of the lighting plant, apart from the power plant, was 390 marks, and the current consumption during one year for lighting was 177 kw. hours at 40 pfgs. = M 70·80

In the case of another farm of 60 acres, nineteen incandescent lamps were installed in the dwelling-house, stalls, barns, lofts, and cellars. No figures are given for the cost of the lighting installation, but the current consumption during 12 months for lighting was 102 kw. hours at 40 pfgs. = M 40·70.

Electric Power.

As in the case of electricity for lighting, electricity for power may be produced on the farm itself, or, as is more generally the case, taken from a central station for public supply. In the latter case single-phase, two-phase, but more usually three-phase alternating current is supplied. Alternating current has the great advantage over direct current for power distribution that its pressure or tension can be raised or lowered by means of simple stationary apparatus known as transformers. Motors designed to work on low-tension electrical mains are both cheaper and safer than those designed to work on high tension mains; while, on the other hand, electrical transmission at high pressure is much cheaper than similar transmission at low pressure. The employment of transformers therefore enables the dimensions of the transmission line and its cost to be kept as low as possible. The energy losses in the transformers are small, and the necessary alternating current motors and generators are cheaper than machines of similar sizes for direct current.

It was, in fact, the development of the three-phase alternating current system that made possible the great development in the distribution of electricity that has taken place in recent years. Its use enables motors of the squirrel-cage type to be employed for most classes of work. These motors have no commutators or rubbing parts of any kind other than bearings to get out of order, and they are therefore ideal for agricultural purposes.

All mechanical work consists in overcoming resistance, and to reduce to the smallest amount the cost of the energy necessary for such work it is necessary to employ agricultural machinery of the most suitable type and electric motors and accessories designed to meet the working conditions met with. Co-operation between the agricultural implement manufacturer and the electrical engineer in this question of design is of great importance if the best results are to be obtained. It is safe to say that the German farmer had at his disposal in the period immediately preceding the war electrical material designed specially to meet his conditions costing little to purchase, involving little cost for attendance, and when portable of a type that could be brought in an easy and convenient manner to those places where the work was required to be done. Some idea of the size of motor necessary for the usual farm operations may be obtained from the following table:—

Ploughing—40 to 80 approx. h.p.
Threshing—3 to 90 approx. h.p., depending upon the size, construction, and output of the threshing machine, and upon the accessories; *i.e.*, cleaning gear, straw press, automatic binder, &c.
Chaff cutting—2 to 10 approx. h.p., depending upon the output and accessories, such as sieve, cleaning apparatus, elevator, &c.
Flour mill—2 to 10 approx. h.p., depending upon the fineness of the flour and the size, output, and system of the mill.
Corn cleaning—1 to 3 approx. h.p., depending upon the type and size of the cleaners.
Potato crushing—0·5 to 1 approx. h.p.
Oil-cake breaking—0·75 approx. h.p.
Oat crushing—2 approx. h.p.
Turnip crushing—2·5 approx. h.p.
Water-pumping—1 to 3 approx. h.p., depending on the quantity of water to be pumped and the height.
Sewage pumping—1 to 2 approx. h.p.
Sack hoists—2 approx. h.p.

Electric motors are also employed for many secondary agricultural purposes and for rural industries and trades

where, since the power demands are very fluctuating and the working period generally short, their advantages are particularly great. Approximate sizes of motor suitable for such trades may be obtained from the following table:—

Dairy work—Churns and kneading machines of large size.
Approximate h.p., 3 to 5.
Cart-making and joinery—Lathes, band saws, circular saws, drilling machines. Approx. h.p., 3 to 5.
Sawmills—Circular and frame saws, grindstones. Approx. h.p., 3 to 8.
Lock-making and smithies—Lathes, drilling machines, grindstones, bellows, ventilators. Approx. h.p., 1·5 to 3.
Bakeries—Kneading machines. Approx. h.p., 1·5 to 3.
Butchery—Meat-beating, mincing, and sausage-making. Approx. h.p., 2 to 3.
Printing works—Steam press. Approx. h.p. 1 to 3.

The following, among other advantages, are claimed for electrical driving on the farm where the motors and accessories are designed for the work they have to do, and the most suitable type for each purpose is chosen. These remarks particularly apply where three-phase motors are employed.

The motors are simple in design, and their first cost is low; thus, a 15 h.p. portable electric motor cost before the war less than one-third of the price of a steam or petrol traction engine of the same size.

They may be fixed in any position without expensive foundations, and may be readily started by merely closing a switch or turning a starting handle, no time being lost in heating or in turning round a crank-shaft as with heat engines.

For a given output the motors are small and light, and therefore portable and particularly suitable for agricultural work where the operations are of a temporary character and the work has to be carried on in different parts of the farm.

The power absorbed when running idle is very little, and a large overload capacity is provided to deal satisfactorily with fluctuating loads. The wear and tear is also small, and little care is required to run them beyond attention to lubrication. Finally, the even turning torque and freedom from reciprocating movement and its accompanying shocks have special advantages in particular cases, as for threshing and corn grinding.

In view of the absence on a large scale of electrical distribution for agricultural purposes in rural districts in this country, it may be well to describe in some detail the various elements of a typical Continental installation. In this connection reference may be made to Fig. 1, which gives a good representation of the distribution of electricity from a long-distance power-station and its connection to a motor in the field. On the left-hand side of the figure will be seen a permanent overhead three-phase transmission system carried on poles, which supplies electricity throughout the agricultural area from a central power-station. Temporary wires are shown connecting this high-tension overhead line to a transformer mounted in a wagon, and seen in front of one of the poles. The high-tension current is changed in this transformer to low-tension current, and this low-tension current is fed through a cable, which can be seen lying on the ground, to a portable motor carried in a horse-wagon and shown on the left-hand side of the picture. This motor drives a threshing-machine by belt. The distance between the transformer and the motor may be as much as a mile, and the low-tension cable which connects the two is, for short lengths, carried on a drum mounted in the motor-wagon, and for longer lengths on a "creel" suitably mounted on a special wagon.

A description in detail of each element of such an installation is given under its separate heading.

(To be continued).

FLAME REACTION OF SELENIUM AND TELLURIUM.

By HARRY B. WEISER and ALLEN GARRISON.

In a recent communication, Papish (*Journ. Phys. Chem.*, 1918, xxii., 430, 640) has extended the observations of Bancroft and Weiser (*Ibid.*, 1914, xviii., 213, 281) by showing that elementary selenium and tellurium can be precipitated on a cold object from flames charged with compounds of these elements. The introduction of compounds of both selenium and tellurium into the hydrogen-air flame imparted characteristic flame colorations in distinct zones. Analogous to the conclusions reached by Bancroft and Weiser, Papish concluded that "processes of dissociation, reduction, and oxidation are back of the luminescences in the different zones." The investigations were not carried to the point where it could be said with any degree of certainty what specific chemical reaction was responsible for a given luminescence. This seemed unfortunate, particularly in view of the fact that the colorations of the different zones in the flames of selenium and tellurium were apparently quite sharply defined. Accordingly, this investigation was undertaken to determine if possible the causes of the different luminescences. The experiments with selenium will first be considered.

Experiments with Selenium.

The Hydrogen-in-air Flame.—Papish introduced elementary selenium and the oxide and hydride of the element into the hydrogen-air flame and obtained the results given in Table I.

For the purpose of familiarising ourselves with the various colours as well as their location in the flame, the experiments of Papish were repeated and extended. Hydrogen from a cylinder was passed through a horizontal hard-glass tube, the end of which was bent upward and supplied with a platinum tip approximately 4 mm. in diameter. The hydrogen was ignited at the tip, and the flame was adjusted to a height of approximately 10 centimetres. By heating the metal or its salts in the hard-glass tube the vapours were carried into the flame in the stream of hydrogen and imparted to it three quite distinct colours in different regions. First, blue in the inner region surrounding the zone of unburned gas; and a deeper shade of blue in an outermost shell seeming to be not more than 4 mm. in thickness. This shell extended from the base of the flame to two-thirds of the distance to the tip. Second, a reddish coloration in a mantle between the colorations of blue. Third, a greenish tip. Selenium may be precipitated as a red coating on a cold object such as a porcelain casserole held in certain portions of the flame. In this manner it was found that free selenium existed in the inner blue and the red portions of the flame but not in the greenish tip. From this tip white fumes of selenium dioxide were seen to rise. The pure oxide was condensed as a film on a cold sheet of mica held in the tip.

TABLE I.

Substance volatilised.	Luminescence.	Deposit on cold object.
SeO_2	Deep blue	Se
H_2Se	Very faint blue	None
Se	Blue	Se.
SeO_2	Pale blue	Se
H_2Se	Deep blue	Se
Se	Violet	Se
SeO_2	Greenish (*a*)	None
H_2Se	Greenish	None
Se	Greenish (*b*)	None

(*a*) Becomes red if much selenium dioxide is volatilised.
(*b*) Occasional red flashes.

The flame luminescences were quite noticeably affected by varying the amount of substances introduced into the

flame (Bancroft and Weiser, *loc. cit.*; cf. Mitscherlich, *Pogg. Ann.*, 1864, cxxi., 487; Wüllner, *Ibid.*, 1863, cxx., 164; *Wied. Ann.*, 1879, viii., 599). When only a very small amount of a substance was added the blue colour in the inner core appeared paler blue and the red luminescence was absent. The addition of an excess of the dioxide cooled down the flame and the white fumes modified the blue coloration. An excess of elementary selenium likewise modified the blue coloration and increased the amount of red luminescence.

The effect of cooling the flame was quite marked. When a coil of heavy copper wire, previously cleaned, was placed around the flame, thus conducting away part of the heat, the green and reddish colorations faded, leaving the blue predominant. A somewhat similar effect was produced by compressing the flame longitudinally between two cold sheets of mica. Since the latter is transparent it was possible to view the flame as if a longitudinal section had been cut from the centre. Because of the cooling effect the red and green disappeared entirely, leaving the section of the blue flame with a dark inner core of unburned gas. When the flame was compressed horizontally by a single sheet of mica it could be viewed from above. The cooling caused the red and green light to disappear, leaving a dark centre of unburned gas surrounded by a ring of blue light that was deeper blue around the outer edge.

Selenium chloride and selenium bromide imparted to the flame the same colours as the metal and the oxide.

It will be noted that in the main our observations confirm those of Papish except that the latter did not call particular attention to the marked effect on the coloration of varying the amount of materials added to the flame. As pointed out, this not only affects the flame temperature and hence causes a variation in the velocity of certain reactions; but it also modifies the flame colorations. When there is a possibility of more than one colour of light being produced in a flame, each colour has an apparent influence on the others, so that what is actually seen is the resultant mixture of colours. In certain regions of the flame one reaction may predominate to such a degree that the modification is altogether inappreciable; while in other regions the effect may be so marked as to indicate a distinct luminescence. The violet coloration observed by Papish in the flame charged with selenium was not a distinct luminescence but was a mixture of red and blue in the right proportion to make violet.

The effect of varying the amount of substance added to the flame was brought out quite clearly in an experiment with hydrogen selenide. A method similar to that used by Papish was employed in this experiment. Hydrogen from a cylinder was conducted through the side arm of a 500-cc. suction flask containing 200 cc. of water. The flask was fitted with a two-hole rubber stopper supplied with a funnel tube that dipped below the surface of the water and with a platinum-tipped glass tube. After lighting the hydrogen at the tip, aluminium selenide was introduced into the flask through the funnel tube. The selenide reacted with water evolving hydrogen selenide, which was burned with the hydrogen. In the presence of but little hydrogen selenide the inner zone appeared faintly blue as Papish observed. When the amount of hydrogen selenide was increased by opening the flask and adding to it a quantity of aluminium selenide, the entire flame was quite similar to those previously observed. The inner zone assumed the same blue colour, and from this region elementary selenium was precipitated as in flames charged with the metal or the oxide.

Particular attention should be called to the shell of deep blue around the outermost portion of the flames to which selenium or its compounds were added. This might easily be overlooked.

The Bunsen Flame.—Selenium and its salts were introduced into the Bunsen flame by volatilising them in a stream of air which was led into one of the air ports at the base of the burner. The colorations produced were similar to those in the hydrogen-air flame. As before, the blue luminescence around the inner core seemed paler than that nearer the outside of the flame. In order to determine whether this was due to the coloured zones through which the observations were made the two cones of the flame were separated by means of the Smithells separator. It was observed that the sheath of blue surrounding the inner core was distinctly paler blue than the luminescence in the outer zone where oxygen was in excess.

The Air-in-hydrogen Flame.—The experiments with the flame of air burning in hydrogen were carried out in an apparatus constructed and manipulated as follows:—A hole one centimetre in diameter was blown in the bottom of a 1000-cc. round bottom flask and was supplied with a platinum tip. The flask was inverted and held in place by a clamp. The one-hole stopper in the neck was supplied with a platinum-tipped inlet tube that could be moved up and down at will. Hydrogen was conducted into the flask through a side arm blown in the neck; and air through the tube in the stopper. After washing the flask free from air the hydrogen was ignited at the tip. The air-inlet tube was then forced through the flask into the flame and a gentle current of air turned on. A flame of air burning in an atmosphere of hydrogen was obtained simply by drawing the air-inlet tube down into the flask. When selenium or its salts were introduced into this flame by vaporising them in the current of air, it was found that there was no green coloration and but very little red in the flame. There was, however, a narrow blue mantle which clung closely to the inner core where air was in excess. In an experiment to be described later on, it was found that the red luminescence resulted in part from the glowing of the vapours of elementary selenium. Since this reddish glow was not apparent in the outermost part of the flame where selenium was in excess, it was evident that the temperature in this region was not sufficiently high. An attempt was made to raise the temperature of the entire flame by substituting oxygen for air. This was found to be impracticable, however, since the glow from the highly-heated platinum tip masked the luminescence.

The Chlorine-in-hydrogen Flame.—In order to determine whether oxygen was necessary for securing the blue luminescence, telluric chloride was introduced into the chlorine-in-hydrogen flame obtained by substituting chlorine for air in the apparatus decribed in the preceding paragraph. Some metallic tellurium was placed in a hard glass tube through which the stream of chlorine passed. On heating, the element was converted into the chloride which was swept into the flame imparting to the outer mantle a distinct blue coloration unmixed with red or green. The coloration in the inner zone was masked by the greenish yellow hydrogen-chlorine flame.

The Luminescence of Selenium Vapours.—Since the vapours of selenium are coloured one should expect them to glow when heated as do the vapours of iodine. (Evershed, *Phil. Mag.*, 1895, v., 39, 465; cf. Paterno and Mazzucchelli, *Atti. Accad. Lincei*, [5], 1908, 17, II., 428; Bancroft and Weiser, *Trans. Am. Electrochem. Soc.*, 1914, xxv., 121). As a matter of fact, Evershed found this to be the case. To determine the intensity and colour of this luminescence a few grms. of selenium were placed in the bottom of a hard-glass test-tube 2 cm. in diameter and 25 cm. in length. The element and the tube above it were heated until the selenium boiled vigorously. The heated vapours coming in contact with the hot tube emitted a reddish glow which corresponds to the reddish luminescence observed in the hydrogen-air flame. These observations were made in the dark room and the flame which was used to heat the element was extinguished to make sure that the vapours were actually glowing instead of reflecting light.

Combustion of Selenium.—When selenium was heated in air or hydrogen it burned with a blue flame. The experiment was carried out as follows:—Two grms. of powdered selenium were placed near the centre of a piece of hard-

glass tubing 2 cm. in diameter and 35 cm. in length. Oxygen from a cylinder was passed slowly over the metal while it was being heated with a blast lamp. When the temperature was sufficiently high the selenium burst into a blue flame of a shade identical with that in the hydrogen flame charged with selenium compounds. When more strongly heated a reddish glow appeared just above the surface of the element. By heating the tube to a greater length it was found that the tip of the blue flame became greenish. White selenium dioxide was formed and deposited in the cooler portion of the tube.

In order to determine whether the reverse reaction of reduction emitted a characteristic glow, an intimate mixture of selenium dioxide and aluminium powder was heated. The speed of the reduction was varied by varying the relative amounts of oxide and aluminium; but in no case was a characteristic luminescence obtained.

The Colour of Selenium Dioxide Vapours.—From the above experiments it was suspected that the greenish coloration appearing in the tip of the hydrogen flame must be connected in some way with the oxide after its formation which was complete in the blue flame. The fact that the oxide but not the element could be precipitated from the greenish tip also pointed to this idea. The colour of the heated vapours of selenium dioxide were observed by sealing a few grms. of the oxide in a hard-glass tube in an atmosphere of oxygen and heating in a blast. At a comparatively low temperature the oxide vapourised filling the tube with a greenish yellow colour. On cooling the greenish colour faded and the white crystals of the oxide redeposited on the walls of the tube.

Experiments with Cathode Rays.—In order to study further the luminescent reactions of selenium, the action of cathode rays on the element and its oxide were tried. Lewis (*Astrophys. Journ.*, 1902, xvi., 31) studied the effect of cathode rays on certain metals in a cathode tube constructed in such a manner as to isolate the effect of the cathode rays from the effect of the current. Under these conditions, with elementary sulphur, selenium, and tellurium he obtained "an almost imperceptible blue glow."

The cathode tube used in these experiments consisted of a vertical portion into which was sealed the disk anode and the cathode; and a horizontal portion enlarged into a bulb below the cathode. One end of the horizontal portion was constructed and to it was sealed a stop-cock tube which connected with the pump. Substances were introduced into the apparatus from the opposite end of the tube, which was closed with a cap making a ground-glass connection. The tube was evacuated with a mercury pump. With substances having a low vapour pressure at ordinary temperatures no difficulty was found in getting and maintaining a cathode vacuum with this apparatus.

The bottom of the cathode tube was first covered with a layer of crystalline selenium, after which the entire apparatus, including the pump, was filled with hydrogen. This was done for the purpose of excluding oxygen. The surface of the metal apparently did not luminesce under the influence of the cathode rays; but the vapours throughout the bulb emitted a reddish glow very similar to that obtained by heating the vapours. Under the influence of the rays the metal volatilised and red amorphous selenium was deposited on the sides of the tube. In this experiment as carried out no attempt was made to isolate completely the effect of cathode rays from the effect of the current, and the latter unquestionably has some effect. It should be stated, however, that no reddish glow was obtained in a "blank" experiment in which the cathode tube contained nothing but hydrogen.

The effect of the presence of oxygen on the luminescence was next tried by introducing oxygen into the cathode tube before carrying it down to a cathode vacuum. The presence of oxygen introduced a blue luminescence along with the red, which gave a violet effect similar to that obtained in the flame. The element was then removed and selenium dioxide put in its place. Under the influence of the rays a portion of the oxide dissociated and the recombination produced throughout the tube a blue luminescence that was distinctly more marked than in the previous case, where only a trace of oxygen was present. (Wiedemann and Schmidt, *Wied. Ann.*, 1895, lvi., 243; Wilkinson, *Journ. Phys. Chem.*, 1909, xiii., 691). When the deep blue colour was present, selenium dioxide collected as white crystals on the sides of the cathode tube. It was thought that a sudden lowering of the pressure while the discharge was passing might withdraw some oxygen leaving selenium in excess. To accomplish this the cathode tube was shut off by means of the stop-cock and the space between the tube and the pump was evacuated as low as possible. When the stop-cock was opened the pressure in the tube was suddenly diminished, and immediately the blue colour became a violet showing the presence of red luminescence; and amorphous selenium deposited on the tube instead of the oxide. If the bombarding was continued more oxide was dissociated and the violet gradually gave place to blue.

In order to show that compounds other than the oxide would give a blue luminescence in the cathode tube an attempt was made to use selenium tetrabromide and selenium tetraiodide. Owing to the volatility of these compounds it was found impossible to get a cathode vacuum at ordinary temperatures.

(To be continued).

NOTICES OF BOOKS.

Volumetric Analysis. By Charles H. Hampshire, B.Sc. (Lond.), F.I.C. Second Edition. London: J. and A. Churchill. 5s.

This is a small book of 121 pages on "Volumetric Analysis" especially written for students in pharmacy, although efforts have been made to include other matter which would be useful to those studying for the profession of analytical chemistry.

After introductory remarks on the making up of standard solutions and the use of indicators, accompanied by a short perusal of the sources of error that are likely to occur, the book is roughly divided ito three sections:—(1) Those reactions dealing with "Acidimetry and Alkalimetry," (2) "Oxidation and Reduction," and (3) "Precipitation Reactions."

Each section is accompanied by examples of titrations which a pharmacist would be likely to carry out during his work, and are based upon the requirements of the British Pharmacopœia.

At the end of the book are a few miscellaneous exercises which are useful.

The book is exceedingly well paragraphed, and each paragraph commences in black type with what the paragraph contains, which is a great asset. On the whole the book has been well thought out, and should be a great help to students.

BOOKS RECEIVED.

"Volumetric Analysis." By Charles H. Hampshire, B.Sc. (Lond.), F.I.C. Pp. 127. London: J. and A. Churchill, Great Marlborough Street. 1919. 5s. net.

"Senior Practical Chemistry." By W. H. Bausor, M.A. Pp. viii+217. London: University Tutorial Press, New Oxford Street. 1919. 3s. 6d.

"Lecture Demonstrations in Physical Chemistry." By Henry S. van Klooster, Ph.D. Pp. vi+196. London: Williams and Norgate, 14, Henrietta Street, Covent Garden. 1919.

"Explosives." By E. de Barry Barnett, B.Sc. (Lond.), A.I.C. Pp. xv+241. London: Baillière, Tindall, and Cox, 8, Henrietta Street, Covent Garden. 1919. 12s. 6d. net.

"The Hydrogenation of Oils." By CARLETON ELLIS, S.B Second Edition. Pp. viii+767. London: Constable and Co., Ltd., 10, Orange Street, Leicester Square, W.C. 1919. 36s. net.

"A Treatise on British Mineral Oil." Editor J. A. GREENE. Pp. xi+233. London: C. Griffin and Co., Ltd., Exeter Street, W.C. 2. 1919. 21s. net.

"Principles of Electric Spark Ignition in Internal Combustion Engines." By J. D. MORGAN, A.M.I.C.E., M.I.E.E. Pp. iii+88. Crosby Lockwood and Son, 7, Stationers' Hall Court, Ludgate Hill, E.C. 4. 1919. 8s. 6d. net.

"Organic Chemistry for Students of Medicine" By JAMES WALKER, LL.D., F.R.S. Second Edition. Pp. xi+332. Gurney and Jackson, 33, Paternoster Row, London. 1919.

"The Manufacture of Chemicals by Electrolysis." By ARTHUR J. HALE, B Sc., F.I.C. "A Treatise of Electro Chemistry." Ed. by J. BERTRAM BLOUNT, F.I.C. Pp. xii+80. Constable and Co., Ltd., Orange Street, London, W.C. 1919. 6s. net.

"Stereo-chemistry." By ALFRED W. STEWART, D.Sc. Second Edition. Pp. xiii+277. Longmans, Green, and Co., 39, Paternoster Row, London. 1919. 12s. 6d. net.

NOTES.

APPOINTMENT.—Sir Henry Alexander Miers, D.Sc. F.R.S., Vice-Chancellor of the University of Manchester has been appointed by an Order of Council dated October 16, 1919, to be a member of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.

APPEAL.—On behalf of the ex-service men who laid aside their careers at the call of duty, I make a strong appeal to you to aid them to fit themselves fully for the highest posts in the great professions. The Government have decided to supplement private effort by means of Maintenance Grants under the Training Grant Scheme, which has been described in the Press and elsewhere. Training for professional qualification is usually best undertaken by service in an office or works, and it is in many cases the custom to charge a premium for pupils who take up such service. More openings for training are urgently wanted, and many ex-service men cannot now afford to pay premiums. These men have proved themselves ready to give up everything. Their sacrifice cannot be measured in money. But it can be repaid in part. I urge you to think of your debt to them as their premium, and to waive for them the usage of the profession, as many public-spirited firms have already done. For over four years the normal supply of fully trained men has been stopped or diminished. More must be obtained in the next few years than ever before, if the profession is to recover its strength and face the economic struggle that is before the whole nation. I ask you, therefore, to make room for pupils to the utmost of your capacity, and to aid the Appointments Department in the work of resettlement, by telling them of what you can do to help. (Communications should be sent to the local office of the Appointments Department, the address of which can be obtained at any Post Office, or from the Appointments Department, St. Ermin's Hotel, Caxton Street, Westminster, S.W. 1).—R. S. HORNE, Minister of Labour, Montagu House, Whitehall, S.W. 1.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.—Sir William J. Pope, F.R.S., Professor of Chemistry in the University of Cambridge, delivered an address entitled "The Photography of Coloured Objects," at the opening meeting of the new Chemical Section of the Society on Friday, October 24. Mr. R. H. Clayton explained the objects aimed at by the Chemical Section, and urged the need for industrial research. Sir Henry A. Miers F.R.S., Vice-Chancellor of the Victoria University of Manchester, presided over a large and enthusiastic meeting. On Tuesday, October 21, the Manchester Chemical Club, under the Presidency of Mr. R. H. Clayton, was incorporated with the Manchester Literary and Philosophical Society. A new Chemical Section of the Society has been formed.

THE September issue of the *Industrial League Journal* is the most interesting and instructive that has yet been published. Sir Robert Hadfield, Bart., contributes a most interesting article on "The Industrial League and Progress." This issue contains 76 pages of printed matter, the bulk of which is taken up with a verbatim report of the three days' Conference of Employers and Employed held in Birmingham during August, which is of a most interesting character and well worth wide distribution. Captain E. Gill, M.C., contributes an article on "A Trade Union Memorial of Freedom and Peace." The Editor, dealing with "Profiteering and Manufacturers," cites the recent resolution passed by the Boot Manufacturers Federation on the limitation of profit, and refers to the fusion of the Industrial League and Industrial Reconstruction Council.

MEETINGS FOR THE WEEK.

Tuesday, November 4.

Mineralogical Society, 5.50, (Anniversary Meeting). "Villamaninite, a new Mineral," by Dr. W. R. Schoeller and A. R. Powell. "Occurrence of Phenacite and Scheelite at Wheal Cock, St. Just, Cornwall," by A. Russell. "New Crystal Forms on Pyrites, Calcite, and Epidote," by L. J. Spencer. "A Curious Crystal from the Binnenthal," by Dr. G. F. Herbert Smith.

Wednesday, November 5.

Society of Public Analysts, 8. "Egyptian Bricks," by G. Rudd Thompson. "Analysis of Brazilian Zirconium Ore," by A. R. Powell and W. R. Schoeller. "Halogen Absorption of Turpentine," by Ethel M. Taylor.

Thursday, November 6.

Institution of Electrical Engineers, 5.30. (At the Institution of Civil Engineers, Great George Street, Westminster). Inaugural Address by the President, Mr. Roger T. Smith, at 6 p.m.

Chemical Society, 8. "The Peroxides of Bismuth," by R. R. Le G. Worsley and P. W. Robertson. "Properties of Ammonium Nitrate—Part I. The Freezing-point and Transition-temperatures," by T. M. Lowry and R. G. Early. "Some 1:3-Benzodiazolearsinic Acids and their Reduction Products," by R. R. Baxter and R. G. Fargher.

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THE CHEMICAL NEWS.

Vol. CXIX., No. 3108.

THE RADIO-ELEMENTS AND THEIR CLASSIFICATION.*

By Mdme. P. CURIE.

The hypothesis according to which radio activity is an atomic property of matter has given rise to a method of searching for new elements based upon this property. The first elements thus discovered by Curie and myself were polonium and radium, but subsequently about thirty radio-active elements have been discovered, and it has been shown that they are not stable, but in course of time undergo spontaneous decomposition. They exist in only very small quantities, except in the case of uranium and thorium, but their chief chemical characteristics are known, and it has recently been found possible to allocate them to positions in the table of the periodic classification of the elements.

The number of elements known before the discovery of radio-activity was about 80. These could all be arranged, in order of increasing atomic weight, in eight columns in superimposed rows, in the Periodic Table of Mendeleeff. In each of the columns, numbered o to 7, elements of the same valence and of analogous chemical nature occur. Although the classification is not perfect it shows the relationships of the elements, and proves that this is determined by certain still unknown general laws. The "rare earths" are exceptions to the general rules; they have similar chemical properties, although in order of atomic weight they follow one another in the interval between barium and tantalum, and consequently they are usually separated from the rest of the table. Column VIII. is formed of elements of peculiar character; they are arranged in groups of 3, each group to a certain extent playing the part of a single element, like the rare earth group.

There are many vacant places in the table, the two last rows in particular being very incomplete, while the last of all contained only uranium and thorium, substances possessing the highest atomic weights (238·5 and 232·4). Several of these vacant places belong to the radio-active elements, radium, for example, occupying the empty place in the last row, in the column of the metals of the alkaline earths, as a homologue of barium.

The new radio-active elements may be classified in various ways. Firstly, their mean life may be considered, or the time T, proportional to the mean life, which is necessary for the reduction of any quantity of the substance to half its value. This quantity, called the period, plays a very important part, for it determines the possibility of separating a radio-active substance in the pure state in sufficient quantity for study with the spectroscope and the determination of the atomic weight. From many points of view the most important radio-active substances are those of long period, such as uranium, thorium, radium, ionium, actinium, and, in a lesser degree, radium D, mesothorium, radio-thorium, and polonium. But the magnitude of the period does not seem to be connected with the chemical nature of the element, and, at any rate at present, cannot be employed to explain chemical analogies.

The radio-active substances occur in the solid and gaseous states, the three radio-active gases being known as emanations. They are regarded as inert gases, for it is not possible to make them enter into chemical combination. They all condense at the temperature of liquid air. The solid products of the spontaneous transformation of an emanation constitute what is called its active deposit.

A particularly interesting method of classifying the radio-active substances consists in arranging them in families in order of filiation. There are three families, the heads of which are uranium, thorium, and actinium, as shown in Table III. This table shows the profound analogy which exists in the succession of the transformations in the three families. The emission of α-rays consists in the violent expulsion of an atom of helium, accompanied by the recoil of the remaining atom, which in this case acquires enough kinetic energy to be collected at some distance from the source if the projection takes place *in vacuo*. The atomic mass of the resulting atom is about four units below that of the atom which has undergone the transformation. The emission of β-rays consists in the expulsion of electrons, which does not cause an appreciable change of mass, although it leads to a profound modification in the properties of the atom. It is thus a case of the emission of an essential and not a peripheral electron, as when the atom is simply ionised. In the emission of β-rays the parent substance and the derived element may be regarded as exhibiting a special atomic isomerism, analogous to molecular isomerism. Experience has shown that terms which correspond with one another in their radiation also exhibit chemical analogy and may be regarded as forming part of the same chemical group.

It has been known for some time that the radio-active elements undergo electrolysis, and can be displaced from their solutions by suitable metals. Thus the active deposits of the emanations can be dissolved in acids and then precipitated on metal laminæ placed in the solutions. Recent researches have enabled us to classify the radio-active elements according to their electro-chemical character, and have shown that the corresponding terms of the radio-active families behave similarly in this respect. The series includes very easily oxidised substances like radium, very easily reduced substances like polonium, and intermediate substances.

Interesting results have been obtained with regard to the valency of the radio elements. This can be deduced by Nernst's formula when the coefficient of diffusion of an electrolyte and the mobility of the two ions which form it are known. Thus, if D is the coefficient of diffusion, K the mobility, *n* the valency, F 96,500 coulombs, R the constant of perfect gases per grm. molecule, and T the absolute temperature, $\frac{D}{K} = \frac{RT}{nF}$. Radio-active substances behave normally as electrolytes, except that in certain cases there is a tendency to form colloidal aggregates. It is found that the corresponding terms of the families of radio-elements have the same valency, and, moreover, this valency is exactly that which would be expected from the study of their chemical properties. Thus, all the data furnished by the application of electro-chemical methods to the study of the radio-elements confirm the conviction that they possess well defined chemical individuality, and in this respect cannot be differentiated from ordinary elements. It has been proved that the properties of the radio-elements enable them to be arranged in a coherent and logical manner in the classification table. A careful examination has shown that (i.) when a radio-active transformation takes place with emission of α-rays, the resulting element, which has an atomic weight 4 units lower than the mother substance, is displaced two columns in the direction of decreasing atomic weight, one column being always skipped. (ii.) When a radio-active transformation occurs without emission of α-rays, the resulting element has the same atomic weight as the mother substance. It is displaced one column only, in the direction of increasing atomic weight. This rule applies to transformations in which β- or β- and γ-rays are emitted, as well as to those which are called "rayless," and which are probably accompanied by a feeble emission of β-rays. In an α-ray transformation the element pro

* Abridged from *Le Radium*, 1919, xi.,

duced is usually more electro-positive than he mother substance, while the reverse holds good for β-ay transformations. According to these rules an α-ay transformation corresponds to a diminution of valency of two units, and a β-ray transformation to an increase of one unit, if the principal valency is taken as the valency. (iii.) The radio-elements form groups of substances of the same chemical and electro-chemical properties, each group playing the part of a single element in the system. A similarity of radio-active properties indicates classification in the same group, but the converse is not necessarily true.

The following is the classification of the radio elements in groups of the same chemical properties:—

I. *Uranium Group.*—Valency 6, Column 6. Radio-elements:—Ur I. and Ur II. Typical substance uranium, of atomic weight 238·5.

II. *Thorium Group.*—Valency 4, Column 4. Radio-elements:—Thorium, Radio-thorium, Uranium X, Uranium Y, Ionium, Radio-ionium. Typical substance thorium, of atomic weight 232·4.

III. *Uranium X_2 Group.*—Valency 5, Column 5. This substance has a period of only 1·1 minute, and constitutes a new chemical type. It was discovered by Fajans, and has also been called brevium.

IV. *Radium Group.*—Valency 2, Column 2. Radio-elements:—Radium, Mesothorium I, Thorium X, Actinium X. Typical substance radium, of atomic weight 226.

V. *Group of Gases.*=Valency 0, Column 0. Radio-elements:—Emanations of Radium, Thorium, Actinium. Typical substance radium emanation.

VI. *Actinium Group.*—Valency 3, Column 3. Radio-elements:—Actinium, Mesothorium II. Typical substance actinium.

VII. *Polonium Group.*—Valency 6, Column 6. Radio-elements:—Polonium, Radium A, Thorium A, Actinium A, Radium C′, Thorium C′. Typical substance polonium, of supposed atomic weight 210.

VIII. *Bismuth Group.*—Valency 5, Column 5. Radio-elements:—Radium E, Radium C, Thorium C, Actinium C. Typical substance bismuth (inactive), of atomic weight 208.

IX. *Thallium Group.*—Valency 3, Column 3. Radio-elements:—Radium C″, Thorium D, Actinium D. Typical substance thallium (inactive), of atomic weight 204.

X. *Lead Group.*—Valency 4, Column 4. Radio-elements:—Radium B, Thorium B, Actinium B, and Radium B. Typical substance lead, of atomic weight 207·1.

If the rules enunciated above are applied to the cases of polonium, thorium C′, radium C″, thorium D, and actinium D it is found that the elements obtained by the transformations all belong to the lead group, and Soddy and Fajans have suggested that ordinary lead is a mixture of substances of different atomic weights, and think that possibly the same may hold good for the other inactive elements of the system. They believe that groups of elements of the same nature, occupying the same position in the System, but of different atomic weight, exist. These elements are supposed to be "non-separable," and have exactly the same chemical properties and the same spectrum. It is not very probable that they have actually exactly the same properties, but it seems more likely that the separation is very difficult.

All emissions of α-rays lead to the formation of helium, and recent experiments have shown that its production from a given quantity of polonium for example is exactly proportional to the number of atoms transformed calculated on the basis of the law of spontaneous destruction. It may be possible that the atom of helium is a sub-atom, from which the elements are formed. The lighter atoms frequently have an atomic weight which is a multiple of 4, so that they may be groups of helium atoms, while others are formed with the aid of hydrogen. J. J. Thomson has suggested that the atoms are composed of electrons, arranged in rings round a central positively charged nucleus, and Rutherford has shown that the dimensions of this nucleus must be so small that it may be regarded as a point. The author believes that two kinds of electrons are present in the atoms—*peripheral* electrons which play a part in the relations of the atoms with the exterior, and are used in the emission of radiation, in electrical conduction in metals or ionised gases and in thermal exchanges; while the *essential* electrons are much more firmly bound, and are only manifested in the emission of β-rays. The fundamental difference between these two classes consists in the fact that an atom can lose one or more peripheral electrons without changing its nature, while the emission of a β-ray destroys the structure of the atom. It seems reasonable to suppose that of the several rings of peripheral electrons it is the external ring which determines the valency, and J. J. Thomson supposes that the positive valency is represented by the number of electrons in this ring, which is always less than 8, while the negative valency is the difference between this number and 8. So when an atom loses an α-particle which represents two elements of positive change, it must in order to remain neutral lose two peripheral electrons so that its valency is decreased by two units. When an essential electron (β-ray) is emitted by the nucleus the atom takes up another peripheral electron, and the positive valency increases by one unit. The objection may be made that in α-ray transformations the resulting atoms are not neutral but have a positive charge; experience shows however that in a very perfect vacuum the charge shows a tendency to disappear, and thus it must be due to phenomena which follow the transformation and are determined by the presence of gas.

The conclusion that may be drawn from these observations appears to be that Radio-chemistry, with the study of radio-active transformations, is the science of the structure of the atoms and of their genetic relations. The radio-elements reveal to us a world hitherto veiled in mystery; as yet we have seen only a glimpse of it, but we can legitimately foretell a magnificent revelation in it.

METHOD FOR ESTIMATING PHOSPHORUS IN STEEL CONTAINING VANADIUM.

By J. MAITCHELL, B.Sc. (Dun.).

Weigh out 2 grms. of steel into a 500 cc. flask, and dissolve in 90 cc. of nitric acid (sp. gr. 1·2), boiling or simmering until all nitrous fumes are driven off. Now add N/10 potassium permanganate solution until a permanent brown precipitate of manganese oxide is thrown down. Place the flask in a water bath, and cool to below 20° C. Run in from a burette N/10 ferrous ammonium sulphate until the brown precipitate goes into solution, and then, until solution is a bright green, with no trace of blue in it. Add 1 cc. excess. 20 cc. 0·96 ammonia are then added, and the solution shaken until the precipitated ferric hydroxide is redissolved, keeping the flask in the water bath all the time. Add 60 cc. of a special faintly ammoniacal ammonium molybdate solution, and after closing the flask with a rubber bung, shake *vigorously* for three minutes. Remove the bung, and allow the solution to stand for twenty to thirty minutes. Filter the precipitated phospho-molybdate off, wash free from acid, transfer pad and precipitate to clean flask. Add 80 cc. distilled H_2O, shake to distintegrate the pad and run in excess of standard caustic soda. When the yellow precipitate has all dissolved in the caustic soda titrate the excess of latter with standard sulphuric acid, using phenolphthalein as an indicator.

Remarks.—To prevent the vanadium coming down with the phospho-molybdate and giving a dark orange precipitate, the precipitation should be carried out at a temperature below 20° C. The advantages of the method are that it is quick, not taking more than three-quarters of an hour, unless the carbides are difficult to get into solution,

nd also accurate enough for laboratory practice as is demonstrated by the results given in Table I.

TABLE I.

No.	1·2 HNO_3 added. Cc.	0·96 NH_4OH added. Cc.	Special molybdate added. Cc.	Equiv. V per cent.	P per cent present.	P per cent found.	Error per cent.
1.	90	20	60	0·271	0·024	0·0245	+0·0005
2.	90	20	60	1·571	0·057	0·059	+0·0020
3.	90	20	60	2·188	0·122	0·1245	+0·0025
4.	90	20	60	1·846	0·016	0·0165	+0·0005
5.	90	20	60	1·954	0·042	0·0435	+0·0015

Time for precipitation, one hour.

In Experiment 1 the British chemical standard "V," a chrome-vanadium steel was used, while the others were ordinary steels which had been analysed for P by the usual phospho-molybdate method by capable analysts. The vanadium was introduced into these by adding ammonium metavandate in the solid form. For simplicity's sake the vanadium present has been calculated to the equivalent percentage, using 2 grms. of sample. It was afterwards found that the time for precipitation was too long, and that twenty to thirty minutes were enough for necessary accuracy.

To study the effects of the different reagents used on the method a series of experiments were carried out, and the results and conclusions drawn are appended (Table II.)

TABLE II.

No.	1·2 HNO_3 added. Cc.	0·96 NH_4OH added. Cc.	Special molybdate added. Cc.	Equiv. V per cent.	P per cent present.	P. per cent found.	Error per cent.
6.	90	20	60	2·366	0·036	0·036	Nil
7.	90	20	60	2·366	0·036	0·032	−0·004
8.	90	20	60	2·366	0·036	0·0295	−0·0065
9.	90	10	60	2·543	0·051	0·051	Nil
10.	90	20	60	2·543	0·051	0·050	−0·001
11.	90	40	60	2·543	0·051	0·026	−0·025
12.	90	20	40	2·610	0·042	0·0085	−0·0335
13.	90	20	50	2·610	0·042	0·041	−0·001
14.	90	20	60	2·610	0·042	0·0415	−0·0005

Time for precipitation, fifteen minutes.

Effect of Ferrous Ammonium Sulphate.

Experiments 6, 7, and 8 were carried out to study the above effect. The quantities added, of ferrous ammonium sulphate, were, after dissolving the precipitated MnO_2 and obtaining a bright green solution, 1 cc., 6 cc., and 9 cc. respectively. It is observed from the results that too great an excess of sulphate has a detrimental effect, although not very great. The surprising part is that ferrous ammonium sulphate, by its presence, is generally supposed to tend towards giving high results in phospho-molybdate determinations, yet from these results and others not quoted the error is on the negative side. Perhaps the effect would have been more noticeable had the equivalent vanadium percentage not been so high, as it required 16 cc. of the sulphate to take into solution the brown precipitate of MnO_2 and reduce the vanadic acid to the hypovanadic state.

Effect of Ammonium Hydroxide.

Experiments 9, 10, and 11 show the effect of varying the amount of ammonia added.

Experiments 9 and 10 both gave good results on this particular steel, although for lower phosphorus contents 20 cc. were found to be generally more suitable. When 40 cc. were added only half the phosphorus present was precipitated. This was most probably due to the fact that, owing to the ammonia neutralising its equivalent amount of free nitric acid the latter was not present in sufficient quantity. In steels containing vanadium it is found that more free nitric acid is required in the determination than in an ordinary plain carbon steel.

Effect of Varying the amounts of Molybdate.

Cf. Experiments 12, 13, 14.

Experiments 13 and 14 gave very good results.

Experiment 12 furnished a remarkable result, as a difference of only 10 cc. of the special molybdate solution added resulted in only one-fifth of the total phosphorus being precipitated. Thus the least amount of molybdate which can be used with safety is 50 cc.

Now 50 cc. of this solution contain 4·25 grms. $(NH_4)_2MoO_4$ or 3·12 grms. MoO_3.

Also in 2 grms. of steel we have 0·00084 grms. P.

The weight of MoO_3 required to precipitate the P completely is over 3700 times thu weight of phosphorus present. Again, if one studies the theoretical equation one obtains remarkable figures.

$$H_3PO_4 + 12(NH_4)_2MoO_4 + 21HNO_3 = (NH_4)_3PO_4.12MoO_3 + 21NH_4NO_3 + 12H_2O.$$

From this—

One atom of P requires $12MoO_3$.

31 grms. of P require 1728 grms. of MoO_3.

∴ 0·00084 grm. of P require 0·0468 grm. of MoO_3.

In theory, 0·0468 grm. of MoO_3 should be sufficient to precipitate the phosphorus, but in practice at least 3·12 grms. or 66 times as much is required.

General Remarks.

In Table I. all the precipitates were allowed to stand for one hour, but it afterwards transpired that fifteen minutes was quite sufficient, and if no particular haste was essential twenty to thirty minutes gave accurate results. This was proved by taking a steel containing 0·057 per cent P, adding 0·1 grm. ammonium metavanadate, and doing two tests by the method given. One was allowed to stand fifteen minutes and the other over an hour.

Results.

Standing fifteen minutes—P found = 0·0555; error, −0·0015.

Standing one hour—P found = 0·0565; error, −0·0005.

ELECTRONS AND HEAT.

By FRED. G. EDWARDS.

IF the atomic ether be incompressible and therefore its atomic volume constant, as described in former papers on "Mechanical Philosophy" (CHEMICAL NEWS, 1919, cxviii., 183, 270), it follows that there can be no contraction or expansion of solids without the relative formation of mechanical electrons in the body of the metal or dielectric, and the formation of these electrons will render the adjoining atoms correspondingly positive as required for the scattering of α-rays. There would be a finite number of electrons per cc. in accordance with the temperature, and their reduction or amplification would be identical with the flow of heat.

Prof. Callendar (B.A. Dundee, 1912) asserts "that the corpuscles of caloric which constitute a current of heat in a metal are very closely related to the corpuscles of electricity, and have an equal right to be regarded as constituting a material fluid possessing an objective physical existence." Neglecting the entropy of the ether and assuming that the entropy of a substance is zero at zero temperature, we are also in agreement when he asserts "that entropy was simply Carnot's caloric under another name, and that the increase of entropy in any irreversible process was the most appropriate measure of the quantity of heat generated." Again, Prof. O. W. Richardson found that a platinum wire heated to between 1020° and 1200° C. gave a thermionic-current curve

which, allowing for difference of scale, was identical with the vapour pressure curve of water between 0° and 90° C.

By hypothesis an electron can only escape by means of an atom of free ether replacing it in the solid, and this is the reversible mechanism of radiation or absorption. Incidentally this shows that in the photo-electric effect the effective energy is the pressure of the ether at the sink, as it should be, and not at the source of light. The present theory is similar in principle to the solid space lattice of Dr. F. A. Lindemann (*Phil. Mag.*, Jan., 1915), which makes the specific heat of the electrons negligible. Admittedly, the existing electronic theory of metallic conductivity cannot meet the attacks which have been made upon it. The Lorentz atom with rotating electrons probably only survives because of its mathematical beauty in relation to the Zeeman effect. Radio-activists strongly favour this catherine-wheel firework type of atom, but Prof. Joly states:—"The halo has established the extreme rarity of radio-activity as an atomic phenomenon. One and all of the speculations as to the slow breakdown of the commoner elements may be dismissed."

If a modicum of the mathematical talent, which, since 1897, has been concentrated on the electronic theory of matter were expended upon the material theory of electricity, every known force would be directly traced to the pressure of the ether, instead of being mostly concentrated inside the atom through the naive assumption of action at a distance. The ether pressure deduced from the velocity of light is $79·6 \times 10^{12}$ tons per sq. inch, or $0·5 \times 10^{24}$ dynes per sq. cm. The spherical diameter corresponding to the repulsion of two electrons distant 1 cm. should be $2·33 \times 10^{-11}$ cm. thus:—

$$(2·33 \times 10^{-11})^4 \times 0·7854 \times 0·5077 \times 10^{-24} = \\ = 1·17 \times 10^{-19} \text{ dynes.}$$

Although the collective motion of electrons constitutes an electric or thermal current, the truth emerges that the number of electrons per cc. in a metal is not a measure of conductivity but of the resistance in the Wiedemann-Franz inverse ratio.

FORMULÆ FOR CALCULATING ADDED WATER IN MILK.*

By LESLIE J. HARRIS

I. For use when fat and solids-not-fat are present in normal ratio:—

$$W = 100 - \frac{N}{8·5} \times 100$$

or—

$$100 - \frac{N}{n} \times 100 \quad . \; . \; \text{J. A. Wanklyn.}$$

II. For samples in which the rising of cream has caused a depression of the solids-not-fat:—

$$W = 100 - \frac{10{,}000\ N}{8·5\ (100 - F) + 3N}$$

or—

$$100 - \frac{10{,}000\ N}{n(100 - F) + f\ N} \quad . \; . \; \text{L. J. Harris.}$$

III. Giving approximate results:—

$$W = 100 - \frac{G + F}{34·5} \times 100$$

or—

$$100 - \frac{G + F}{26} \times 100 \quad . \; . \; \text{H. Droop Richmond.}$$

IV. When the sample prior to watering contained an excess or deficiency of fat caused by the separation of cream, and the extent of the change in composition is unknown:—

$$W = 100 - F - \frac{97}{8·5} N$$

or—

$$100 - F - \frac{(100 - f)}{n} N \quad . \; . \; . \; \text{L. J. Harris.}$$

In each of the above formulæ the first expression gives the added water compared with milk of the "minimum standard (fat, 3 per cent; s-n-f, 8½ per cent); the second is the more general expression.

W is the percentage of added water; F the fat; N the solids-not-fat in the sample; n, f are the standards taken for solids-not-fat and fat; G is the lactometer reading.

* Abstract of a paper in the *Analyst*, Sept. 1919, p. 318.

FLAME REACTION OF SELENIUM AND TELLURIUM.

By HARRY B. WEISER and ALLEN GARRISON.

(Concluded from p. 208).

Discussion of Results.

The three colorations in the flames of selenium will be considered separately.

The Blue Luminescence.—Blue luminescence is produced under the following conditions:—(1) When elementary selenium burns in excess oxygen. (2) Pale blue in the region surrounding the inner cone of the hydrogen-air flame or the Bunsen flame charged with selenium, its oxide, hydride, or halides. In this region air is present but not in excess. (3) A deeper blue in the outer portion of flames in air where there is excess oxygen. This is particularly marked in a sheath surrounding the outermost portion of the lower part of the flames. (4) A narrow mantle close to the inner core of the air-hydrogen flame. (5) In the flame of chlorine burning in hydrogen. (6) When the oxide is acted on by cathode rays. From these results is is evident that the blue colour is always produced when the element is oxidised rapidly enough. Air is unnecessary since the same coloration is obtained in an oxygen-free flame. The lowest oxide of selenium is the dioxide, and this is formed when the element is burned in air or oxygen. When the oxide is acted on by cathode rays a blue luminescence is produced from which it seems probable that the specific chemical action that produces the colour is the reaction from selenium ion to selenic oxide or salt (Wiedemann and Schmidt, *loc. cit.*; Wilkinson, *loc. cit.*

The depth of the blue colour depends on the amount of selenium oxidised in a given space and the rapidity of the oxidation. This accounts for the blue luminescence appearing paler in the inner portion of the hydrogen flame than in the outer portion where there is excess air. When selenium salts are introduced into the ordinary flame they are so readily acted on by the combined dissociating and reducing actions of the flame that some selenium is formed at once and can be precipitated on a cold object held but a short distance from the inner zone of unburned gas. This selenium coming in contact with a relatively small amount of oxygen a little further on, burns in part with a blue luminescence. Beyond this narrow zone in the hottest region of the flame the reverse reaction of dissociation predominates, but this gives place to oxidation again in the cooler outermost portion of the flame. This last oxidation takes place in the presence of excess air, and the luminescence appears deeper blue than it does in the inner zone.

If the amount of selenium added to the flame is very small, only a faint coloration appears in the inner zone. On the other hand, the presence of an excess of the element or compound cools the flame and masks the coloration in proportion to the amount present. The bluest colour in the inner zone should result in the presence of the maxi-

mum amount of selenium that is capable of complete oxidation before reaching the zone of highest temperature where the reverse reaction predominates.

The Red Luminescence.—The red luminescence is produced under the following conditions:—(1) In the hottest portion of flames charged with excess selenium or its compounds. This is most marked midway between the inner and outer cones. Elementary selenium is readily precipitated from this portion of the flame. (2) When the highly-coloured vapours of selenium are heated. (3) When selenium vapour is acted on by cathode rays in a hydrogen-filled cathode tube. Since the vapours of selenium are coloured it is evident that at least a part of the luminescence on heating the vapours is a thermal luminescence; but in view of the fact that a similar glow was obtained in the cathode tube, it is probable that a part of the glow is due to chemiluminescence. A similar conclusion was reached concerning the luminescence of heated sodium vapour. In all probability this is due in part to thermal luminescence (Evershed, *loc. cit.*) and in part to chemiluminescence (Wood, "Physical Optics," 1911, 537, 579). In connection with the flame reactions of sodium, the evidence indicated (Bancroft and Weiser, *Journ. Phys. Chem.*, 1915, xix., 310) that the familiar yellow luminescence was produced at least in part by some stage in the reaction from electrically nautral sodium vapour to sodium ion. It was impossible to specify the reaction more closely since it was not possible to account for all the sodium spectra observed by Lenard (*Drude's Ann.*, 1903, xi., 636) and by Wood and Galt (*Astrophys. Journ.*, 1911, xxxiii., 72). Similarly, we conclude that the red luminescence in the flames containing selenium is due in part to the colour of the vapours, in part to a purely thermal luminescence, and in part to some stage in the reaction from electrically neutral selenium vapour to selenic ion. It is as yet unsafe to specify the reaction more closely, particularly since no quantitative study of the glow spectrum of selenium vapour under various conditions has been made as in the case of sodium vapour. In this connection Lenard (*Drude's Ann.*, 1902, ix., 632) has shown the existence of selenium ions in the hottest portion of flames but not in the outermost regions. As previously pointed out, the amount of the red luminescence is determined by the amount of selenium added to the flame. The coloration may be eliminated almost completely by encircling the flame with a spiral of large copper wire. The part which each of the above mentioned factors contribute to the red luminescence can be decided only by a quantitative study of the flames under various conditions.

The Greenish Coloration.—The greenish coloration occurs—(1) In the outer tips of the hydrogen-air and the Bunsen flames. (2) When selenium is vaporised in a sealed tube. Although solid selenium dioxide is white, the vapours are greenish, from which we conclude that the green colour in the tip of certain flames is not a luminescence at all, but is merely the colour of the dioxide vapours that appear more green because of the reflection of the blue luminescence just below. On cooling the flame the green coloration disappears, since the vapours are converted to a white smoke. A similar phenomenon was observed in the hydrogen-chlorine flame charged with copper salts and in the Bunsen flame charged with a large excess of copper chloride (Bancroft and Weiser, *loc. cit.*). The vapours of the chloride are coloured and impart a coloration to the tip of the flame.

Experiments with Tellurium.

By introducing tellurium compounds into the flame of hydrogen burning in air Papish (*loc. cit.*) obtained the results given in Table II.

The Hydrogen-in-air Flame.—The experiments with the hydrogen flame were carried out in the same manner as previously described for selenium. The flame charged with the element and its compounds consisted of three distinct colours with sometimes a fourth. First, green in the inner cone surrounding the zone of unburned gases; second, an outer mantle of blue that could be modified considerably by the addition of varying amounts of material to the flame; third, a greenish tip; and fourth, in some instances a shade of red between the outer blue and the inner green in the hottest portion of the flame. Tellurium was precipitated as a metallic mirror when a cold object such as a porcelain casserole was held in the inner green or the reddish portions of the flame. It will be seen by referring to the above table that in most respects our observations agree with those of Papish. The so-called lilac colour observed by the latter was not a distinct luminescence but was a mixture of blue and reddish orange in the right proportions. As was true with selenium flames, the respective colours can be modified considerably by varying the amounts of materials added to the flames. Thus Papish ordinarily obtained a lilac coloration, but with excess of selenium he got the reddish luminescence surrounded by blue as we observed. A particular instance of the effect of the quantity of material introduced into the flame was again brought out in the experiments with the hydride. The experiment was carried out as previously described for hydrogen selenide, substituting aluminium telluride for aluminium selenide. A considerable quantity of aluminium telluride was added to the flask and no difficulty whatsoever was experienced in getting a flame with the inner green region similar to the flames to which the metal was added. It was only after the telluride was almost gone that the inner zone took on more of the bluish colour noted by Papish. This same effect was produced by adding a trace of the element to the flame. As will be pointed out in the subsequent discussion of these experiments, these results are in accord with what one might expect.

TABLE II.

Substance volatilised.	Luminescence.	Deposit on cold object.
	Inner zone.	
TeO_2	Green	Te
H_2Te	Blue	Te
Te	Green	Te
	Middle zone.	
TeO_2	Lilac (*a*)	Te
H_2Te	Lilac	Te
Te	Lilac (*b*)	Te
	Outer zone.	
TeO_2	Green	None
H_2Te	Green	None
Te	Green	None

(*a*) Accompanied by red flashes.
(*b*) Also red surrounded by blue when much tellurium is volatilised.

The effect of cooling the flame was quite as marked as in the case of selenium. When a spiral of large copper-wire was lowered around the flame, thus conducting away some heat, the greenish tip faded and all reddish coloration disappeared, leaving only the green inner core surrounded by a mantle of very deep blue. When compressed longitudinally between two sheets of mica, the orange reddish luminescence and the green tip again disappeared. The section, appearing as though it had been cut from the centre of the flame, consisted of a dark core of unburned gas, along the sides of which was a narrow strip of green, followed by one of blue. By compressing the flame horizontally with a single sheet of mica and observing from above, the section was seen to consist of a dark centre of unburned gas surrounded by a circle of green and a narrower rim of blue. Tellurium dioxide was deposited as a white ring outside the circle of flame. From this it seemed likely that tellurium dioxide could be precipitated on a piece of mica held in the greenish tip of the flame. This conclusion was confirmed as the oxide

is much less volatile than the corresponding oxide of selenium and was readily condensed. The molten oxide as well as the vapours were found to be greenish yellow in colour.

The Bunsen Flame.—The Bunsen flame contained the same colorations as the hydrogen flame. When the two cones were separated in the Smithells separator, the inner flame, where air was not in excess, formed a sheath of vivid green unmixed with blue, surrounding the cone. The outer flame where air was in excess was blue with a greenish tip. The latter was less marked than in the ordinary hydrogen flame, probably on account of the lower temperature. For the same reason there was but little reddish in the flame. A more brilliant coloration in both zones was obtained by using volatile salts of tellurium such as telluric bromide and telluric iodide. With these salts were produced an inner flame of very vivid green and an outer deep blue with a faint greenish tip.

The Air-in-hydrogen Flame.—When tellurium was introduced into the flame of air burning in hydrogen, the inner core surrounding the zone of unburned gas was blue, and around it was a mantle of deep green like that observed in the inner zone of the Smithells separator. Metal deposited on the walls of the bulb.

The Chlorine-in-hydrogen Flame.—Chlorine was passed over heated tellurium and the telluric chloride formed was swept into the flame of chlorine burning in hydrogen. An outer mantle of green was obtained identical with that in the same region of the air-hydrogen flame. The inner blue core was indistinct as it was masked by the yellowish chlorine flame.

Combustion of Tellurium.—A few grms. of tellurium were placed near the centre of a hard-glass tube through which was passed a slow current of oxygen. The tellurium was heated until it burst into a flame, the colour of which was greenish blue. The line of separation between the two colours was much less distinct than in the hydrogen flame. However, the flame was more green near the tellurium where the metal was in excess and more blue where oxygen was in excess. By heating to a high temperatnre it was possible to obtain the golden-yellow vapours of tellurium just above the surface of the element. White tellurium dioxide was deposited on the tube beyond the flame.

Since in all cases the green luminescence was formed in the more reducing portions of flames and the blue in the more oxidising regions, it should be possible to decrease the green luminescence to a minimum and to increase the blue luminescence to a maximum by increasing the concentration of oxygen in the region of the hydrogen flame charged with tellurium. To obtain this condition, the platinum-tipped hydrogen tube was jacketed by a tube 3 cm. in diameter and 10 cm. in length. A stopper in the bottom of this jacket-tube served the double purpose of closing the bottom and of holding it concentric with the hydrogen tube. The top of this jacket was about 2 cm. above the hydrogen tip. After lighting the hydrogen and introducing tellurium into the flame, oxygen was run into the jacket from a side arm near the bottom. The oxygen arose and encircled the lower portion of the flame supplying it with an excess of the gas. Under these conditions the flame became almost entirely blue with only a small reddish orange inner core and the usual greenish tip.

No characteristic luminescence was obtained by the rapid reduction of tellurium dioxide with aluminium powder.

Cathode Rays on Tellurium and its Salts.—The experiments with the cathode rays were carried out in the same apparatus as previously described. Metallic tellurium was first introduced into the hydrogen filled tube, which was then evacuated. The glow in the bulb was reddish under the influence of the rays, but the coloration was not so marked as with selenium on account of the greater volatility of the latter metal. When the metal was replaced by the oxide a faint bluish glow was obtained. Telluric bromide was next used with more marked results. When the salt was first bombarded a reddish glow was produced over the surface, which soon disappeared and did not return. The vapours throughout the bulb glowed with a bright blue colour but the luminescence was green near the surface of the bromide. Since the cathode rays decompose the compound into its elements and since tellurium is much less volatile than bromine it seemed plausible, in line with previous experiments, to attribute the blue luminescence throughout the bulb to a relatively higher concentration of bromine, and the green luminescence near the surface of the salt to a relatively higher concentration of tellurium. If this were true it should be possible to exhaust further during the passage of the discharge, thereby decreasing the concentration of bromine. This was done as in the experiment with selenium dioxide, and it was found under suitable conditions that the luminescence throughout the bulb changed from blue to green. The discharge was continued, and after a time the green disappeared, giving place to the usual blue as more telluric bromide was decomposed by the cathode rays. It was hoped to confirm these experiments with telluric iodide; but the salt was so volatile that a cathode vacuum could not be obtained at ordinary temperatures.

Discussion of Results.

There are four colorations in the flames of tellurium to be accounted for. These will be considered in turn.

The Green Luminescence.—The green luminescence is produced under the following conditions:—1. In the inner zone of the hydrogen-air flame and the Bunsen flame charged with tellurium compounds. With volatile salts of tellurium such as the bromide and iodide, this coloration is particularly marked in the zone surrounding the inner core of the Smithells separator. 2. Deep green outer zone in the flame of air burning in hydrogen. 3. Deep green outer mantle in the flame of chlorine burning in hydrogen. 4. Near the surface of the tellurium when the element is burned in oxygen. 5. Under the inflence of cathode rays telluric bromide shows a green luminescence near the surface of the salt where tellurium is in excess. By suddenly lowering the pressure in the tube while continuing the bombarding, bromine is withdrawn and green luminescence fills the tube.

Tellurium differs from selenium in that it forms two oxides TeO and TeO_2 and series of salts corresponding to both oxides. When the element is burned in air or oxygen it goes to the dioxide; but it is altogether probable that the oxidation is stepwise although it does not stop at the monoxide stage. A stepwise oxidation is readily carried out with the halogens. By reference to the data above summarised it will be seen that the green luminescence occurs in the more reducing portions of flames which favour the reaction to tellurous compounds. This is true in every case whether the oxidation is in the presence or the absence of oxygen. Since the green luminescence is obtained in the cathode tube under the conditions which favour the formation of tellurous salt, we conclude that the green luminescence in tellurium flames is due to the reaction from tellurous ion to tellurous salt.

The Blue Luminescence.—The blue luminescence is produced under the following conditions:—1. In the outer zone of the hydrogen-air flame and the Bunsen flame charged with tellurium and its compounds. 2. In the inner zone of the flame of air burning in hydrogen. 3. The flame of tellurium in oxygen. 4. Throughout the greater portion of the hydrogen flame charged with selenium compounds when the lower portion of the flame is encircled with an atmosphere of oxygen. 5. Throughout the cathode tube containing telluric bromide when bromine is in excess. From the above data it is evident that the blue luminescence occurs in the oxidising portion of all flames which favour the formation of telluric compounds. Since the cathode rays on telluric compounds give a blue luminescence under suitable conditions, we conclude that

this luminescence is due chiefly to the reaction from telluric ion to telluric salt.

As in the case of selenium flames the coloration is influenced by the amount of material present in the flame. If but a trace of the element is added to the hydrogen flame complete oxidation may take place in the inner zone, which may then appear more blue than green in colour. In the presence of excess selenium the blue luminescence is modified by reddish, giving it a lilac appearance. If the flame is cooled by surrounding it with a coil of wire the reddish colour disappears leaving a decided blue.

The Reddish Luminescence.—The vapours of elementary tellurium are golden-yellow in colour, and when heated in a quartz tube Paternò and Mazzuchelli (*loc. cit.*) found that an emission spectrum is produced which they considered was a temperature radiation. A reddish glow is obtained with the element in a cathode tube filled with hydrogen before evacuating. Analogous to the reddish luminescence in selenium flames, it is probable that the orange-red colour in the hottest portion of flames from which tellurium can be precipitated, is due in part to the colour of tellurium vapours, in part to thermal luminescence, and in part to chemiluminescence resulting from some stage in the reaction from electrically neutral tellurium vapour to telluric ion. A quantitative study is necessary to determine the part contributed by each of these factors under widely varying conditions.

The Green Coloration.—Tellurium dioxide melts to a geenish yellow liquid. The oxide is much less volatile than the corresponding oxide of selenium and the colour of the vapours is not so marked. However, the greenish coloration in the tip of the flame is unquestionably due to these vapours reflecting the blue luminescence just below them. When the tip of the flame is cooled, the vapours are readily condensed and the green coloration disappears forthwith.

Summary.

The result of this paper may be summarised briefly as follows:—

1. A study has been made of the flame reactions of selenium and tellurium and of the salts of selenium and tellurium.

2. The reaction from selenium to selenic salt produces a blue luminescence which is the most characteristic in flames containing selenium. It is probable that this luminescence is due chiefly to the reaction from selenic ion to undissociated selenic salt

3. The reaction from tellurium to tellurous salt produces a green luminescence; and from tellurous salt to telluric salt a blue luminescence. It is probable that the green luminescence is due chiefly to the reaction from tellurous ion to the undissociated tellurous salt; and the blue luminescence from telluric ion to the undissociated telluric salt.

4. Under certain conditions a reddish luminescence occurs in flames containing selenium that is as a rule less intense than the blue luminescence; and a reddish orange luminescence in the flames containing tellurium that is less intense than either the green or the blue luminescence. Since the vapours of both elements are coloured, it is probable that the reddish coloration in both cases is due in part to the colour of the vapours, in part to a purely thermal luminescence, and in part to some stage of the chemical reaction from the vapours of the element to the tetravalent ion. It is unsafe to specify the reaction more closely until more is known of the glow spectra of the vapours of the respective elements.

5. No characteristic luminescence has as yet been detected for the reverse reactions.

6. A combination of the red and blue luminescence frequently gives a violet or lilac appearance to certain portions of the flames. This must not be mistaken for a distinct luminescence.

7. A greenish tip in the flames in air charged with selenium and tellurium compounds is not a luminescence, but is due to the greenish colour of the vapours of the dioxide, which appear more green by reflecting the blue luminescence just below.

8. Particular attention has been called to the modifying influence on flame colorations by varying the amount of materials added to the flame.—*Journal of Physical Chemistry*, xxiii., No. 7.

ENERGY DISTRIBUTION IN SPECTRA.*

By Prof. JOHN W. NICHOLSON, M.A., D.Sc., F.R.S.

OUR knowledge of the structure of very fine spectrum lines is now on a secure and nearly comprehensive basis, from the point both of theory and of experiment, and it is very remarkable that so little is known of the distribution of energy in these lines, either in individual lines, or as between the different lines contained in the spectrum of any atom. The analysis of the spectra of atoms, theoretically and in the laboratory, is now recognised as the most critical test to which any theory of atomic structure can be subjected, and we have recently had theories of the atom entirely based upon the wave-lengths of the radiations which they emit. A question of equal importance, to which I now wish to direct your attention, is the relative amounts of energy which the atom throws out in the different wave-lengths, for this is well known to vary in some cases very greatly, according to the circumstances under which the atom is excited. I shall describe, in the first instance, a method designed by Dr. Merton for investigating the distribution of energy among spectrum lines, or in the breadth of an individual line, with great accuracy. It is possible by this means to obtain the long-desired object of an absolute scale of spectral intensity, independent of all the ordinary difficulties determined by such matters as the unequal behaviour of the photographic plate for light in different regions of the spectrum. Dr. Merton and I have been working together on this subject for the past three years, and I shall conclude the present discourse with an account of some of the more interesting results which have been reached, after an explanation of the method.

The intensities of spectrum lines have usually been recorded on an arbitrary scale, ranging between 10 and zero, the numbers assigned being at the discretion of the observer, and varying so greatly among different observers as frequently to be of little value for exact knowledge. They depend also very much on the nature of the observation, whether visual or photographic, and in the latter case, on the region of the spectrum to which the line belongs. The sensitivity of a photographic plate varies with the wave-length of the light in a curious manner, and apparently an irregular one not following any simple law. The sensitivity of the eye is also different for different colours.

When the line is outside the visible spectrum, in the infra-red or dark heat region, measurements of intensity can be made with some accuracy by a thermopile or a bolometer. But they are needed more urgently in the visible region at present, not only for the information they will afford regarding the nature of the atom, but also for application to other problems. The subject is very important, for instance, in the interpretation of celestial spectra, and more particularly those spectra of great complexity and variability which are associated with the birth of new stars, from which most of our knowledge regarding such stars must be constructed.

Previous knowledge of changes in spectral intensity under varying conditions was of necessity limited to the great changes. Those changes which are of especial value in connections such as I have mentioned are liable to be of a less conspicuous type, not readily capable of detection by the ordinary photographic or the visual method, and if detected, not capable of accurate measurement.

* A Lecture delivered at the Royal Institution, May 2, 1919.

In the visual region of the spectrum, observations with the bolometer are not satisfactory. The source of light must be very intense in order to produce large deflections in the galvanometer, and only the brighest lines could be dealt with even in this way. Only one line in the spectrum can be experimented upon at a time, and the source of light cannot be maintained constant over a protracted period. The method is, in fact, quite unsuitable, and the spectrophotometer has been tried instead, but no great accuracy is possible, and its use is confined to a very narrow region of wave-length. Moreover, the variability of the source of light is again present.

In adopting any photographic method for quantitative work we must remember that not only does the sensitivity of the plate vary with the wave-length, but also that there is no very definite relation between the density of a photographic image and either the intensity of the light or the time of exposure. If we halve the former and double the latter we do not get the same density of the image, but another which depends on the particular plate used. The grain of a plate also scatters light, and the critical size of the image thus depends on the exposure and intensity of the light. We were early compelled to conclude that accurate measurements of intensity by a photographic method involves the necessity of an equal exposure on the same plate for all the sources of light to be compared, and the method to be described satisfies this necessity.

The spectrograph for producing and photographing the lines of a spectrum is set up in the usual way, which requires no description. A wedge of neutral tinted glass, cemented to another of clear glass so as to form a plane-parallel plate, is mounted in front of the slit. The image of the slit formed by light of any wave-length is thus attenuated towards the part of the slit opposite the thick end of the wedge, where the absorption of light is greatest, and the image ceases to be strong enough to affect the plate beyond a certain specific height which depends on the original intensity, in the beam from the source, of this particular wave-length.

The photograph thus consists, not of the usual spectrum with all lines or slit-images of the same length, but of a spectrum in which all the lines are cut down to specific heights depending on the original intensities, and thus it gives a simultaneous record of all the intensities in the spectrum at any one instant. All spectrum lines have a breadth, due to Doppler effect of the atomic motions in the kinetic theory, and to other agencies. The shape of one of the truncated lines depends on the original law of intensity across the line. This shape may be a wedge, or may be bounded by a more or less rounded curve, from whose nature, if the boundary can be defined sharply, we can deduce mathematically the law of intensity across the original line. Sharp changes of intensity, such as occur when the line has several close components overlapping one another, are detected as peaks or kinks in this bounding curve. The original photograph can be enlarged with considerabls magnifying power, and if the bounding curve on this enlargement is sharply defined, we can obtain its mathematical shape very accurately, and deduce an estimate of the intensity in any part of the line with a great degree of precision. We have been able to show, for instance, that in most of our experiments, such accuracy as one part in 100 has been reached, and it could be increased readily if desired by the use of greater magnification of the original photograph.

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(To be continued).

NOTICES OF BOOKS.

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The use of synthetic perfumes is touched upon, and a good table given showing the chief physical properties of these bodies.

There is an interesting chapter on the antiseptic and therapeutic value of perfumes, giving the results of experiments on the effects of aromatic vapours on various bacilli. The remainder of the book contains a large number of formulæ for the manufacture of perfumes and toilet preparations of all kinds.

The book is illustrated by 32 engravings and is fully indexed.

Lecture Demonstrations in Physical Chemistry. By Henry S. van Klooster, Ph.D. London: Williams and Norgate, 14, Henrietta Street, W.C.

This volume consists of numerous experiments for proving the present conceptions of physical chemistry. Under the heading of Physical Chemistry the author includes general properties of matter, diffusion of gases, osmosis, the ionic theory, actino-chemistry, colloids, &c.

At the beginning of a chapter he gives a short *précis* of the subject under discussion, with a list of sub-headings of what will be found in the following pages; for example, the chapter on "Catalysis" is divided into ten parts, each part relating to a certain type of catalytic reaction.

The author has laid down no rule for the number of experiments given on any reaction, generally he gives more than one illustration.

He has used the knowledge of great chemists, Ostwald, Faraday, Fischer, &c., to a great advantage by using their experiments as a basis for his own demonstrations; when he has merely repeated their work he has provided a good reference where the original may be found.

The method of preparing the experiment is given in great detail, which is a distinct advantage, for in many of the instances given success depends on having the exact concentration of liquid and other minor details.

The title of the book gives the reader an exact idea of its contents. As a handbook for the lecturer it should be a great aid. Its usefulness for the student would be greatly enhanced if the results of the experiments were explained more in detail.

Senior Practical Chemistry. By H. W. Bausor, M.A. *London: University Tutorial Press, New Oxford Street.* 3s. 6d.

This book is written to meet the requirements of students studying for Senior Cambridge Local Examinations in practical chemistry.

The first chapter deals with methods of preparation of some typical chemical compounds and the testing of same. In this way the student should acquire a good idea of the synthesis and analysis of some of the commoner chemical compounds.

The following chapter deals wirh the first principles of qualitative analysis. Qualitative analysis is pursued as a definite branch of study in the third part of the book. Reactions of the metals and the method of analysis of an unknown substance are explained in detail. A valuable table for systematic qualitative analysis is appended to this part.

The second part of the book deals with quantitative analysis; both gravimetric and volumetric methods are lucidly explained.

The book has three useful appendices and a good index.

As a student's book for the Senior Local Cambridge Examinations we can recommend it.

NOTES.

Dr. E. W. Smith, Chief Chemist at the Birmingham Gas Department, was elected Chairman of the Birmingham and Midland Section of the Society of Chemical Industry, but owing to pressure of engagements he finds himself unable to accept the position, and Mr. L. P. Wilson, of Coventry, has been elected, with Dr. R. S. Morrell (Wolverhampton) and Dr. H. W. Brownsdon (Birmingham) as Vice-Chairmen. Mr. J. C. Sheldon (Birmingham) has been appointed Representative and Corresponding Member of the section on the newly-formed Chemical Engineering Group. It is the intention of the section to co-operate closely and sympathetically with that group who are very keen about developing its work. It has arranged for a Conference to be held on April 22 at the Birmingham University on Labour Saving Devices in Chemical Works, and a number of interesting papers, including several from American chemical engineers, will then be read. On November 13 the Birmingham industrial chemists will hold a joint meeting with the Birmingham Metallurgical Society to receive a paper on "Production of Artificial Abrasives in the Electric Furnace."

Mr. W. A. Twine, Chemical Plant Superintendent, Birmingham Gas Works, has been appointed to give a course of 30 lectures this winter at chemical engineering classes at the Birmingham Municipal Technical School. Last year the session made a strong appeal. Mr. Twine has had a wide experience in chemical engineering and technology.

The Committee appointed by the Board of Trade to inquire into the non-ferrous mining industry met on October 23, under the Chairmanship of Mr. H. B. Betterton, M.P., when Mr. H. Rich, a Director of Tincroft Mines, Ltd., and Mr. William Thomas, the General Manager of the Tincroft Mine, gave evidence. In their opinion an amalgamation of the mines in the Central District would be advantageous. Mr. Rich said the Government should make a grant of £1,000,000 for this purpose, and he instanced the advance made by the Government to the Anglo-Persian Oil Company as a precedent. He thought that in view of the services rendered to the country by the Cornish tin mining industry in the time of national emergency, the sympathy of the Government should assume practical shape in the manner indicated. Mr. W. Thomas gave technical evidence as to the position and prospects of the lodes in this area, and generally concurred with Mr. Rich.

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This book, in its fourth edition, forms a useful introduction to the art of perfumery, and a guide for those who are interested in the preparation of perfumes and cosmetics on a small scale. The first part of the book contains brief descriptions of the various plants and other sources from which the aromatic oils, &c., are obtained, together with the principal methods used for their extraction.

The use of synthetic perfumes is touched upon, and a good table given showing the chief physical properties of these bodies.

There is an interesting chapter on the antiseptic and therapeutic value of perfumes, giving the results of experiments on the effects of aromatic vapours on various bacilli. The remainder of the book contains a large number of formulæ for the manufacture of perfumes and toilet preparations of all kinds.

The book is illustrated by 32 engravings and is fully indexed.

Lecture Demonstrations in Physical Chemistry. By Henry S. van Klooster, Ph.D. London : Williams and Norgate, 14, Henrietta Street, W.C.

This volume consists of numerous experiments for proving the present conceptions of physical chemistry. Under the heading of Physical Chemistry the author includes general properties of matter, diffusion of gases, osmosis, the ionic theory, actino-chemistry, colloids, &c.

At the beginning of a chapter he gives a short *précis* of the subject under discussion, with a list of sub-headings of what will be found in the following pages ; for example, the chapter on "Catalysis" is divided into ten parts, each part relating to a certain type of catalytic reaction.

The author has laid down no rule for the number of experiments given on any reaction, generally he gives more than one illustration.

He has used the knowledge of great chemists, Ostwald, Faraday, Fischer, &c., to a great advantage by using their experiments as a basis for his own demonstrations ; when he has merely repeated their work he has provided a good reference where the original may be found.

The method of preparing the experiment is given in great detail, which is a distinct advantage, for in many of the instances given success depends on having the exact concentration of liquid and other minor details.

The title of the book gives the reader an exact idea of its contents. As a handbook for the lecturer it should be a great aid. Its usefulness for the student would be greatly enhanced if the results of the experiments were explained more in detail.

Senior Practical Chemistry. By H. W. Bausor, M.A. London : University Tutorial Press, New Oxford Street. 3s. 6d.

This book is written to meet the requirements of students studying for Senior Cambridge Local Examinations in practical chemistry.

The first chapter deals with methods of preparation of some typical chemical compounds and the testing of same. In this way the student should acquire a good idea of the synthesis and analysis of some of the commoner chemical compounds.

The following chapter deals with the first principles of qualitative analysis. Qualitative analysis is pursued as a definite branch of study in the third part of the book. Reactions of the metals and the method of analysis of an unknown substance are explained in detail. A valuable table for systematic qualitative analysis is appended to this part.

The second part of the book deals with quantitative analysis ; both gravimetric and volumetric methods are lucidly explained.

The book has three useful appendices and a good index.

As a student's book for the Senior Local Cambridge Examinations we can recommend it.

NOTES.

Dr. E. W. Smith, Chief Chemist at the Birmingham Gas Department, was elected Chairman of the Birmingham and Midland Section of the Society of Chemical Industry, but owing to pressure of engagements he finds himself unable to accept the position, and Mr. L. P. Wilson, of Coventry, has been elected, with Dr. R. S. Morrell (Wolverhampton) and Dr. H. W. Brownsdon (Birmingham) as Vice-Chairmen. Mr. J. C. Sheldon (Birmingham) has been appointed Representative and Corresponding Member of the section on the newly-formed Chemical Engineering Group. It is the intention of the section to co-operate closely and sympathetically with that group who are very keen about developing its work. It has arranged for a Conference to be held on April 22 at the Birmingham University on Labour Saving Devices in Chemical Works, and a number of interesting papers, including several from American chemical engineers, will then be read. On November 13 the Birmingham industrial chemists will hold a joint meeting with the Birmingham Metallurgical Society to receive a paper on "Production of Artificial Abrasives in the Electric Furnace."

Mr. W. A. Twine, Chemical Plant Superintendent, Birmingham Gas Works, has been appointed to give a course of 30 lectures this winter at chemical engineering classes at the Birmingham Municipal Technical School. Last year the session made a strong appeal. Mr. Twine has had a wide experience in chemical engineering and technology.

The Committee appointed by the Board of Trade to inquire into the non-ferrous mining industry met on October 23, under the Chairmanship of Mr. H. B. Betterton, M.P., when Mr. H. Rich, a Director of Tincroft Mines, Ltd., and Mr. William Thomas, the General Manager of the Tincroft Mine, gave evidence. In their opinion an amalgamation of the mines in the Central District would be advantageous. Mr. Rich said the Government should make a grant of £1,000,000 for this purpose, and he instanced the advance made by the Government to the Anglo-Persian Oil Company as a precedent. He thought that in view of the services rendered to the country by the Cornish tin mining industry in the time of national emergency, the sympathy of the Government should assume practical shape in the manner indicated. Mr. W. Thomas gave technical evidence as to the position and prospects of the lodes in this area, and generally concurred with Mr. Rich.

The International Institute of Agriculture announces the yield of wheat for 1919 at 519 million quintals in Northern Hemisphere countries producing about one-half of the world's normal crop. This is 44 million quintals (7·8 per cent) below the yield in 1918 for the same countries, and 21 million (3·9 per cent) under the average from 1913 to 1917, but larger than the average yield in the previous period of five years from 1908 to 1912 by 24 million quintals (4·8 per cent). The yield of rye in these countries is 42 million quintals, against 44 millions in 1918, and an average of 34 millions from 1913 to 1917. The combined yield of wheat and rye is therefore, for those countries, 561 million quintals in 1919, as compared with 607 millions in 1918, and an average of 574 millions from 1913 to 1917.

MEETINGS FOR THE WEEK.

Monday, November 10.

Biochemical Society, 5.30. (At King's College, W.C.).
Royal Society of Medicine, 5.30. Presidential Address by Surg.-Rear-Admiral Sir Robert Hill.

Tuesday, November 11.

Royal College of Physicians, 5. "Origins and Development of Arabian Medicine," by Dr. E. G. Browne.

Wednesday, November 12.

Conjoint Board of Scientific Societies, 5: (At Royal Society, Burlington House, W.). Discussion of Draft Report on the Metric System.

Thursday, November 13.

Royal Society, 4.30.
Royal College of Physicians, 5. "Arabian Medicine," by Dr. E. G. Browne.
Institution of Electrical Engineers, 6. (At Institution of Civil Engineers, Great George Street, S.W.). Presidential Address, by Roger T. Smith.
Optical Society, 7.30.

Friday, November 14.

Royal Astronomical Society, 5.
Physical Society, 5.

Saturday, November 15.

Physiological Society, 4.30. (At 8, Hunter Street, Brunswick Square, W.C.).

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THE CHEMICAL NEWS

Vol. CXIX., No. 3109.

THE

EMPLOYMENT OF MICRO-ORGANISMS IN THE SERVICE OF INDUSTRIAL CHEMISTRY.*

A Plea for a National Institute of Industrial Micro biology.

By A. CHASTON CHAPMAN.

When I was invited to contribute to this Conference a paper dealing with the employment of micro-organisms in the service of chemical industry, my first impulse was to decline, on the ground that it would be quite impossible to deal adequately with even a small branch of so wide and complex a subject within the limits of an ordinary scientific communication.

A little reflection, however, sufficed to show that if the temptation to wander too far afield were resolutely resisted, there were one or two aspects of the matter of special importance at the present moment which might very usefully be brought before an audience such as this.

It is, I think, abundantly clear that, during the period of reconstruction on which we are now entering, it will be necessary for this country to strain every nerve to meet foreign competition, and to become as far as possible self-supporting.

It is a truism that the wealth of a country depends on its productiveness, and, for far too many years and in far too many cases, we have been content to act merely as agents when we should have been manufacturers. The war has, I think, brought home to us the folly of such a course, and it behoves us to see that we never again become as dependent as we have been on other countries for so many of our vital necessities.

As a branch of chemical industry, *industrial* micro-biology has not received, in this country, the amount of attention to which its importance entitles it, and in this paper I propose to refer merely by way of example to one or two of what may be called (for want of a better term) the fermentation industries, which have been very seriously neglected in this country, and which it should now be our duty to establish firmly on British soil.

Of all branches of chemical science none, perhaps, has made greater progress during comparatively recent years than the sub-division of organic chemistry to which the term *biochemistry* is now generally applied. Including, as it does, within its purview a study of the chemical constitution of a vast number of naturally occurring compounds, their genetic relationships, their modes of production, and the various transformations which they undergo in the living organism, it will be obvious that the problems concerned are not merely of intense interest, but are frequently of the very highest importance in their relation to chemical industry.

Whilst any attempt to divide chemical processes and chemical products into *vital* and *non-vital*—that is, to assume some special "vital force" operating in living organisms—would be without scientific justification and could scarcely fail to act as a serious obstacle to progress, yet it cannot be denied that, in the great majority of biochemical syntheses and transformations, we are confronted with chemical modes of activity of which, at present, we have but the dimmest conception. When we consider the wonderful synthetic processes accomplished by the leaves of plants under the stimulus of light, the formation of starch or of protein in the growing plant, the conversion of carbohydrates into fat in the animal organism or by some of the microscopic fungi, or any of the numerous instances of enzyme action, and compare the ease and completeness with which these complex transformations are effected at ordinary temperatures with the drastic, clumsy, and often wasteful syntheses of the laboratory, we must realise how far we are still from understanding nature's methods, and how much we have to learn before we can hope to imitate them.

To quote from the late Professor Meldola:—"When we can transform sugar into alcohol in the laboratory at ordinary temperatures by the action of a synthesised nitrogenous organic compound; when we can convert glucose into citric acid in the same way that *Citromyces* can effect this transformation; when we can build up heptane, or cymene, or styrene, or when we can produce the naphthalene or anthracene complex in the laboratory by the interaction of organic compounds at ordinary temperatures, then may the chemist proclaim with confidence that there is no longer any mystery in vital chemistry."

It is true that we are beginning to understand something of the nature of enzyme action, and that many of the changes—particularly those involved in hydrolysis—can be readily brought about by what may be termed, in this connection, "artificial" laboratory methods. It has to be remembered, however, that there are still a great many important natural processes coming under this heading—such, for example, as alcoholic fermentation—which cannot be successfully imitated, and for these we are still dependent on the living organism.

Thus, to take two instances: whilst alcohol and lactic acid can be prepared synthetically, as the result of various purely chemical processes, those processes are at present so costly and so imperfect as to be useless for technical purposes, and we are therefore largely dependent on what may be termed biological methods for the production of those important substances on a commercial scale.

Whether, with the growth of chemical knowledge, the services of the living organism will be ultimately dispensed with, or whether—as I think more probable—those services will be more largely utilised in industrial chemistry, only the future can show. It is sufficient for our present purpose that a number of very important industries are more or less completely dependent upon the activities of certain lowly organisms, and that a very thorough knowledge of the nature of those organisms and of the influence of environment on their chemical activities is essential to efficient and successful factory work.

This brings me to a point to which I wish in this communication to direct special and serious attention, viz., the very inadequate provision made in this country for systematic instruction in industrial micro-biology, and for the study of the innumerable problems on which it bears. In connection with brewing and distilling an immense amount of work has been, and is being done, but the minor fermentation industries have been left very largely to take chance, and to what extent we have been losers by this carelessness and neglect, a reference to one or two industries will show. Let us consider, for example, the manufacture of lactic acid

Although it had been known since the time of Scheele that lactic acid can be prepared from milk sugar, the production of this acid on an industrial scale dates back no more than thirty or forty years. It was in the early days prepared in somewhat considerable quantities in this country and in America, and for a number of years, so far as I can ascertain, little or none was made in Germany. Up to about twenty years ago the Germans seem to have relied almost entirely on the imported product, and I think I am right in saying that a not inappreciable quantity was actually obtained from this country. With the greatly extended commercial use of lactic acid, particularly in the dyeing and tanning industries, the need for new sources of supply became great. To meet this many factories were established, especially in Germany, and a

* Read at the Annual General Meeting of the Society of Chemical Industry, London, July 15, 1919. From *Journ. Soc. Chem. Ind.*, xxxviii., p. 282.

the outbreak of war that country had become a large producer, one firm alone making over 600 tons per annum. Reliable statistical information in regard to the production and importation of lactic acid and its salts is scarcely obtainable, but I am informed on good authority that in 1912 we imported from Germany 513 tons, and that in the following year this had risen to 750 tons. It is clear therefore that not only were we not able to supply our own requirements, but that we were importing from our former customer, Germany, about one-half of the total quantity we needed and the bulk of the remainder chiefly from France, Italy, America, and Holland. It is not easy to arrive at an exact estimate of the amount of lactic acid used in this country, but I think it may be taken that at the outbreak of war it was something approaching 1500 tons per annum, and of this only a very small proportion was being made here. It may, of course, be said that these quantities, after all, are not great, and that as compared with many industrial products, the money value involved is very small. This is, of course, quite true, but it has to be borne in mind that lactic acid is only one of the biochemical industries to which my paper has reference, and that I am merely using it as an illustration of the general principle that unless we are content to allow our industries to pass into the hands of our competitors we must spare no effort to raise those industries—great and small—to such a condition of technical perfection that our position as manufacturers is absolutely unchallengeable.

I need scarcely remind you that lactic acid is manufactured on the large scale by the bacterial decomposition of various carbohydrates. According to the usual text-book equations, one molecule of milk sugar first undergoes hydrolysis and then yields four molecules of lactic acid, whilst one molecule of dextrose similarly gives rise to two molecules of the acid. That the reactions involved are not by any means as simple as these equations would appear to indicate is, of course, obvious, but the important fact from the technical point of view is that through the agency of selected micro-organisms, or more probably through the agency of the enzymes which they elaborate, a yield which falls not very far short of that indicated by the above equations can, under favourable conditions, be obtained. The actual process of manufacture roughly comprises five steps:—(*a*) The preparation of the sugar solution in a condition suitable for fermentation; (*b*) the bacterial fermentation of this solution under suitable conditions in the presence of an excess of finely-divided calcium carbonate and the production of calcium lactate; (*c*) the decomposition of the calcium lactate with sulphuric acid; (*d*) the filtration and washing of the calcium sulphate resulting from the preceding operation; and (*e*) the concentration of the lactic acid to the required strength.

It is not within the scope of this paper to describe in detail the manufacture of lactic acid, and I may therefore omit all reference to the nature of the plant and to the many precautions which have to be taken if an acid of good quality is to be produced. My object is rather to show that no matter how good the plant may be, how carefully all the purely chemical operations may have been carried out, or with what success the various engineering difficulties may have been surmounted, the success or failure of the manufacture depends on the selection of the right organism and on a precise knowledge of the conditions under which that organism is capable of doing its best work. The production of lactic acid from carbohydrates is, in fact, a general property of a large number of bacteria, but of these only a comparatively small number are capable of industrial application. This fact brings us face to face with the first difficulty and one upon the proper solution of which successful working very largely depends. I refer, of course, to the selection of the organism to be employed. It is clear that the intending manufacturer may adopt one of two courses. He may himself take steps to isolate in some way or other an organism capable of giving him the results he requires, or he may endeavour to procure the necessary culture from someone else. In the first case it is obvious that he must be possessed of considerable knowledge, not merely of bacteriological technique, but also of the life history, general characters, and probable habitat of the various lactic bacteria. He must, obviously, be prepared to devote a considerable amount of time to this preliminary work, and even then it is by no means certain that he will obtain the organism which is capable of giving him the result he requires—that is to say, the maximum yield of lactic acid in the minimum time. The alternative to this uncertain and difficult method of proceeding is to obtain the required organism from some person or institution. This is a point with which I propose to deal more fully a little later, but it will perhaps suffice to say here that any one intending to commence the manufacture of lactic acid in this country would find it very difficult, except perhaps as a personal favour, to obtain a pure culture of a carefully selected lactic bacterium, together with full instructions as to the precise fermentation conditions to be observed in order to get the best results. This last point is one of considerable importance, since for every organism there is a particular set of conditions, the observance of which is absolutely essential to successful working. It is necessary, for example, to know what soluble form of nitrogen should be supplied and in what quantities, what temperature should be maintained, what amount of aeration, if any, should be adopted, and what steps should be taken to prevent the acidity from rising beyond the point at which the activity of the organism becomes inhibited. It will, I think, be clear that the acquisition of this knowledge often involves a series of scientific investigations such as could only be carried out successfully in a laboratory or institution devoted to that particular kind of work. Although a vast amount of study has been devoted to the bacteria producing lactic acid, and although there are several organisms that have acquired industrial fame owing to their activity, it is not by any means certain that still more active bacteria may not yet be discovered. In support of this I may, perhaps, mention that in the course of a somewhat prolonged investigation I myself succeeded a few years ago in isolating a lactic acid bacterium which gave not only a rather higher yield, but worked very much more rapidly than the most vigorous organism which had previously been obtained. From what I have said it will, I think, be clear that if lactic acid is to be manufactured successfully and to be sold profitably at a competitive price, it is essential that steps should be taken to secure in the first place the right organism, secondly to grow it under the most favourable conditions, and finally to maintain it in a state of biological purity. I may say, without fear of contradiction, that these conditions of success, whilst well recognised by our manufacturers, are by no means universally observed. A good deal of lactic acid is, in fact, being turned out in a very haphazard manner, the quality being poor and the cost of production unnecessarily high.

If the conditions of the lactic acid industry are by no means as satisfactory as they should be, the conditions under which butyric acid is manufactured are very much worse. Much less work has been devoted to a study of the various bacteria producing butyric acid and to the determination of the conditions under which they exert their maximum activity. It is not too much to say that the majority of the manufacturers of butyric acid very rarely have any precise knowledge of the organisms they are employing, and as a result the yield of butyric acid is often very low and its quality poor.

Even in the important and ancient vinegar industry the same want of precise knowledge obtains. Each manufacturer has in process of time produced a certain variety of organism which appears to answer his purpose, but of the life history of which he is usually profoundly ignorant and which he takes no special pains to obtain or to preserve even in an approximately pure condition. There can, I think, be very little doubt that a careful study of the acetic acid bacteria with special reference to their

industrial properties would be productive of great benefit to the vinegar industry. Not only is it probable that different species, if used in pure culture for acetification, would give vinegars of different flavour, but it is also tolerably certain that particular organisms might be found to be especially suited for use in certain types of apparatus, and that the working losses which are so serious in many vinegar factories might be very considerably reduced.

I might refer to many other industries depending on the activities of micro-organisms, but I have perhaps said enough to show that even in the case of industries which have been in existence for a considerable time the empiricist is still far too much in evidence. This, I think, is largely due to the fact that facilities are wanting for the proper training of workers in the biochemical industries, and that there are no means by which such workers can keep in touch with modern views and modern developments.

There is not, in fact, in this country, nor (so far as I am aware) in the British Dominions, any institution devoted to a subject which is admittedly of such enormous technological importance.

Assuming such an institution to come into existence, it may be useful to consider for a few moments what ground its activities might cover and what functions it might perform.

In the case of brewing and distilling, we are dealing with two very ancient industries, in which scientific investigation had perforce to follow for a considerable time in the footsteps of practical experience. In those industries the practical man knew what results he required, and, as a rule, how those results could best be obtained, and it was left for the scientific man merely to supply the explanation. Even in these ancient industries, however, a point was reached at which further progress was impossible without highly specialised scientific investigation, and what Pasteur, Hansen, and many others have done in this field of inquiry is too well known to need any further reference here.

In the case of the wine industry, however, very much less scientific work has been done, and at the present time there is in my view an enormous future for the systematic investigation of the wine-making industry, from the biological side.

In the dairy industry, and particularly in connection with cheese-making, in agriculture, in bread making and the pressed yeast industry, in tanning, in the treatment of sewage, and in the study of certain plant diseases, to mention only some of the fields in which micro-organisms play an overwhelmingly important part, the scope for investigation is almost unlimited.

The first, and perhaps the most important, object of the institute which I have in my mind would be to provide for the systematic prosecution of original research in connection with the above industries, and, in fact, with any industry in which micro-organisms or enzymes play an important part.

That a great deal of very valuable work of this kind has been done in this country is well known to all who are familiar with the subject; but the institutions in which this has been done are scattered, and there can be no doubt that far better results would be obtained if the many closely related problems connected with the activity of micro-organisms and of enzymes could be studied in a single institution adequately provided with all the necessary appliances and specimens, and where the various workers in these closely-associated fields would have the opportunity of discussing their problems with one another.

In the next place, the Institute would serve as a centre for the specialised training of men intending to devote themselves to the teaching of micro-biology and biochemistry in our Universities and technical schools, and also for the practical instruction of factory managers and other technical employés engaged in the various biological industries

I am, of course, aware that a good deal of work in this direction is being done in existing institutions, but there is an absolute want of co-ordination, accompanied by overlapping and waste of energy, and, above all, there is the important fact that the men engaged in teaching these subjects, although possessing the highest academical qualifications, are frequently wanting in the necessary practical experience and knowledge. There is, moreover, very frequently a great scarcity of the living specimens necessary for experimental laboratory work.

It would not, for example, be at all easy to name any existing institution in this country in which the science and technology of the manufacture of, say, vinegar, lactic acid, or butyric acid could be taught in such a way as to provide a proper and adequate equipment for a man desirous of devoting himself to any one of those industries.

What I may perhaps describe as the chemical and chemical engineering sides of the subject are, of course, provided for, but for the teaching of the much more important biological side the provision at present existing is imperfect and entirely inadequate.

A further function which the proposed Institute might fulfil would be that of providing breweries, distilleries, and other factories with any required organisms in pure culture and in sufficiently large quantities for industrial purposes. The technical manager of any factory in which biological processes are employed would find it a very great convenience to be able to obtain at any required moment a working quantity of the particular organism on which his operation depended. At the present time scarcely any such facilities exist in this country. In France the want is to some extent met by the *Service des Levures* of the Pasteur Institute, which is in the habit of supplying brewers, distillers, wine growers, cider manufacturers, and lactic acid makers with the necessary cultures, and in addition to this there are several private institutions, covering more or less the same ground. In Germany the work is done by the Institute for Fermentation Industries, and in one or two other countries there are more or less well-known private establishments; such as Jörgensen's Laboratory in Copenhagen.

Then, again, the Institute would serve to house as complete a collection of industrial micro-organisms in pure culture as could be got together. No such collection exists in Great Britain, and scientific workers, industrialists, and others are compelled to apply to their friends on the chance that someone may happen to have a specimen of the organism required, or to endeavour to obtain it from the Centralstelle für Pilzkulturen in Amsterdam, or (before the war) from the Fermentation Institute in Berlin, from Kral, of Prague, or from some other foreign public or private institution. The time and trouble involved in a quest such as this will be well remembered by those who have been compelled to undertake it. As one who happens to possess a fairly large collection of living saccharomycetes and allied organisms in pure culture, I can myself bear witness to the frequency with which these organisms are required and to the difficulty of obtaining them conveniently. It must be remembered that these cultures are to the micro-biologist what pure chemicals are to the research chemist, and it is surely not too much to ask that one set at least of these important living specimens and reagents should be at the service of biological workers and others in this country. I have reason to believe that the demand on the part of British and Colonial workers alone is not inconsiderable, and it would most certainly increase if the supply were readily forthcoming. I am aware that the labour involved in maintaining such a collection as I am indicating would be considerable, but it is of the routine kind, necessitating the employment of merely a few carefully trained laboratory attendants, working under the supervision of the keeper of the collection. The Institute would further serve as a central bio-chemical library. At the present time there is happily a proposal to form one large library devoted to chemical literature, and there is a very general feeling that all overlapping and unnecessary

multiplication should be avoided. With this policy of concentration I am in the fullest agreement; but I think that it will be generally admitted by all who know that the literature of the subject with which I am dealing is of a very highly specialised character, and that many of the most important volumes and some of the periodical journals are not, as a matter of fact, readily obtainable in any of our existing libraries. On this point I speak as one who has on more than one occasion experienced the difficulty of obtaining access to works for which the general demand is small, and which are too costly and too highly specialised to appeal to the majority of the members of the library committees of our scientific societies. Finally—and this would possibly not be one of the least important of its functions—the proposed Institute would serve as a central home for British micro-biological science, and as the institution to which all workers in this field of natural knowledge in every part of our Dominions would apply for information, to which they could send rare specimens for identification or for investigation, and to which they could, subject to proper safeguards in the matter of priority, communicate any discovery of importance. The subject in its botanical aspects is not one with which I can claim anything more than a very limited acquaintance; but in our Colonies and overseas Dominions there must be many occasions on which mycologists—official and otherwise—would experience the advantage of such an institution, and whilst obtaining information themselves might render great national service by contributing to our knowledge of the nature of many fungoid plant diseases. As an example of this side of the Institute's functions, reference may be made to the so-called "mineral yeast" which was manufactured in considerable quantities in Germany during the war and used for human food purposes. From statements published during the war in the German technical Press, it appeared that one of the professors of the Institut für Gärungsgewerbe in Berlin received in the early part of 1916 from a pupil of his on the Eastern Front a small specimen of a growth found on the stumps of certain trees in that district. After considerable investigation it was found that the growth contained an organism which exhibited some very interesting features. Thus, not only did it produce under certain conditions considerable proportions of fat, but it also had the property of building up crude protein from ammonium salts (without any form of organic nitrogen) in the presence of phosphoric acid and traces of compounds of potassium and magnesium. Inasmuch as ammonium salts could be obtained readily from the air, and since the carbohydrates resulting from the acid hydrolysis of wood could be used as a source of carbon, it was clear that this organism rendered it possible in the short space of 36 hours to build up fat and protein from such comparatively cheap raw materials as ammonium phosphate and the acid conversion products of sawdust. This organism is not a true yeast—that is to say, it does not belong to the genus saccharomyces and it does not produce alcohol. As the result of the numerous statements appearing in the German technical Press, Mr. Fred. Wissler, chairman of the Marmite Food Extract Co., Ltd., interested himself in this matter, and a product was obtained from which, after some considerable difficulty, an organism was isolated, which, if not identical with the German "mineral yeast," possessed very similar properties. The conditions essential for the growth of this yeast were minutely studied, and it was produced on a large experimental scale. By a special process the Marmite Food Extract Company found it possible to prepare from it a food extract closely resembling extract of meat in its chemical and physical properties, and so one had placed in one's hands the possibility of manufacturing, through the agency of this microscopic organism, and in the course of a few days, a food extract closely resembling meat extract from such materials as glucose or converted sawdust, ammonium phosphate, and traces of certain other mineral salts. I mention this merely to show how important at times it might be to have a central institution to which interesting biological specimens from various parts of the world might be sent for examination and study.

I am well aware of the excellent work in the domain of industrial micro-biology which is being done in a number of isolated institutions, such as the Lister Institute in this country, in one or two well-known American colleges, in the Pasteur Institute in Paris, in the Institute for Fermentation Industries in Berlin, in the Carlsberg Laboratory in Copenhagen, and in some others which it is not necessary to specify. Each of these institutions, however, deals with this immense subject in certain of its aspects only, and as compared with the scheme which I am advocating they suffer from the great disadvantage that there is no co-ordination, and that consequently a combined attack on any of the big problems which are calling for solution is rendered very difficult, if not impossible. I might refer to still other advantages attaching to a central institution, but I think I have said enough for my purpose. I desire to make it clear that I do not lay claim to any originality, since the idea which I am putting forward is one which must have presented itself to many working biologists, and is similar to one advocated some years ago by Paul Lindner, of the Institute for Fermentation Industries in Berlin. It need scarcely be said that the institute Lindner advocated would have had its home in Germany, and I think it behoves us in this country to take steps to establish on British soil an institution which, although primarily intended to meet the needs of British workers, might ultimately receive the support of many of our American and Continental allied colleagues. If my paper should be the means of provoking discussion, and should bring the establishment of such an institution a little nearer, I shall feel myself amply repaid for the labour involved in its preparation.

ENERGY DISTRIBUTION IN SPECTRA.*

By Prof. JOHN W. NICHOLSON, M.A., D.Sc., F.R.S.

(Concluded from p. 218).

The examination of an individual line has also been applied in the case of an "ordinary" discharge, and given the first direct proof of the probability distribution of velocities in the radiating atoms of a gas. This distribution has been taken as a basis by Lord Rayleigh in the elaboration of a precise method of determining the mass of a radiating atom from the breadths of the spectrum lines, a method applied by Buisson and Fabry with great success, when the breadth is measured by methods of interference of light. Our experiments have defined very closely the circumstances in which this method is practicable, and shown that it fails altogether if condensed discharges are employed. In the ordinary uncondensed discharge under low pressure, however, our contours are very accurately parabolic, which fact can be shown to imply a very rigorous probability law of velocities in the atoms, and no other important source of broadening of lines in these circumstances.

The only other application to an individual line which I shall mention concerns the nature of the Balmer series of hydrogen, long believed to be a Diffuse Series, with each line consisting of two close components, hardly separable or not separable at all, with the same interval in frequency between them for every line. We have shown that it is in fact a Principal Series, with the separations decreasing in a calculable way required by theory, conforming also the separation in H_α given by Buisson and Fabry. The method was to use the neutral wedge in combination with another apparatus of extreme resolving power—in this case a Lummer-Gehrcke plate. We can in this way obtain contours for a pair of close components

* A Lecture delivered at the Royal Institution, May 2, 1919.

which cannot be detected visually as a pair, and the actual interval can be deduced by a series of measurements of the joint contour, consisting of two overlapping parabolas. We calculate the position of the vertex of the inner one, and thence the separation, which can, in $H\beta$ be determined within about 0·001 of an Angström unit. The actual separation in this line is as small as 0·030 A., and the present method could measure accurately a much smaller separation.

We pass now from the phenomena of structure and intensity of a single line to those involving a comparison of different lines. Here the behaviour of the plate for different wave-lengths must be dealt with. But it so happens that every plate can be calibrated by throwing on to it not only the whole spectrum under examination, but the radiation—a continuous spectrum—from the positive crater of the carbon arc. The energy distribution in this case is known from Wien's law when the temperature of the arc is known, as it is very closely. On the slide you will notice the curious contour bounding this spectrum, largely due to vagaries in the sensitivity of the plate. Above it is the helium spectrum on the same plate. To obtain an absolute scale of intensities down the helium spectrum, independent of all sources of error due to apparatus, we only need to compare the heights of the lines with the corresponding heights directly below them in the carbon-arc spectrum. It is in fact logarithms of intensity which the heights represent, and the differences of height represent powers of a definite *factor* entering into the intensities, so that the photographs give no visual impression of the enormous differences of intensity which occur. For example, the line of wave-length λ 3888, a Principal line in the helium spectrum, appears quite short on the photograph, but is actually the most intense in the spectrum. Absorption in the apparatus is strong in this region. One of our conclusions, in fact, is that Principal Series deserve their name even in elements which appeared hitherto to be exceptions, in that they do contain, for the visible region, a preponderant part of the radiated energy.

It is not necessary to use the carbon arc in every subsequent experiment. We can by its means calibrate the helium spectrum under conditions easily reproduced, and subsequently take this as our standard, especially when the work projected is the variation of the helium spectrum under changing conditions of excitation. Some of the remaining slides indicate the unexpected character of some of these variations. It would not be possible in this Discourse to give anything like a complete account of the phenomena of this class already investigated, and I shall therefore confine myself to some of those which are most striking. In the first place we may notice the spectrum of a mixture of hydrogen and helium or neon. The fundamental phenomenon which this method has detected is what we have called "transfer of energy along a series." For instance, in the Balmer series of hydrogen, produced from pure hydrogen under "ordinary" conditions, there is a perfectly definite intensity relation among the lines $H\alpha$, $H\beta$, and so on; but in the presence of helium this is disturbed, and the ratios $H\beta / H\alpha$, $H\gamma / H\beta$, $H\delta / H\gamma$, . . . are notably increased. In other words, more energy tends to be emitted in the form of the more refrangible rays, at the expense of the less refrangible. It is interesting to speculate as to how far this process can be carried, for its logical outcome is a radiation from hydrogen concentrated at λ 3646, the limit of the Balmer series. We have not in fact examined the matter from this point of view.

Neon produces the same effect on the hydrogen spectrum, the first recorded evidence being an experiment of Liveing and Dewar, who found in 1900 that it was possible to observe more of the violet members of the Balmer series when neon was present. We have made quantitative measurements of the effect in various cases, and in one experiment, for instance, the neon was found to make $H\beta$ $\frac{6}{5}$ as strong, $H\gamma$ $\frac{9}{5}$ as strong, and $H\delta$ $\frac{11}{5}$ as strong, in relation to $H\alpha$. But I shall not enter into further numerical detail. A particularly interesting fact is that the effect of a small trace of an impurity is often diametrically opposite to that of a large quantity, and causes the transfer of energy to take place in the opposite direction along the spectrum. There are evidently two quite different mechanisms of interaction possible between the atoms of the two gases—a problem I commend to the chemist for investigation.

But it is not necessary to mix a gas with another gas in order to produce the energy transfer. It can be achieved otherwise, as some further slides I have here will suffice to show. We have made many measurements of intensity, more especially in the spectrum of pure helium, of the lines from a pure gas as dependent on the part of the tube they arise from, and on the conditions of excitation. We shall only consider one or two of the more interesting results which arise from a comparison of three spectra of helium—(1) The "ordinary" spectrum, or the spectrum given by the capillary of a vacuum tube containing helium at about a millimetre pressure, excited by the discharge from an induction coil without capacity or spark gap; (2) The bulb spectrum, obtained by putting a small condenser and a very small spark gap in parallel in the circuit; and (3) the capillary spectrum, with a spark gap and a strong condensed discharge. In both (2) and (3), the transfer of energy to the more refrangible members of a series takes place very strongly. In the Diffuse Series, the transferred energy goes in (3) mainly towards increased breadth of the line, but in (2) mainly towards enhanced central intensity—two very different effects. The Sharp and Principal Series show the same transfer quite definitely, though on a smaller scale, and the effect in these series is more closely confined to enhancement of the central intensity.

The most striking enhancements produced by the condensed discharge in helium occur with the lines λ 4472 and λ 4388, which are precisely the helium lines apt to be found abnormally strong in the spectra of some of the planetary nebulae. Some other experiments we have made, on the spectrum of helium at very low pressure, indicate that these lines, together with the line λ 5015 more frequently quoted, are the strongly enhanced lines also in these circumstances. If the two sets of circumstances occur together, λ 5015 is not especially strong, but the others are enhanced for both reasons. We have in fact been able to demonstrate that the preculiar "nebular" spectrum of helium could be produced in the laboratory by a combination of the condensed discharge with an extremely low pressure.

I shall not discuss the spectra of gases as dependent, in their intensity relations, on pressure. The time required would be prohibitive, and my object is to indicate the range of work now open to precise investigation, rather than to give any complete account of the phenomena which the method has yet indicated or elucidated. One remark must, however, be made in connection with high-pressure spectra. We investigated the intensity distribution in a helium tube at the extraordinary pressure of 42 mm. Except for the trace of hydrogen which came out of the electrodes during the discharge the helium was pure. Yet the hydrogen spectrum was nevertheless predominant on the plate, and fourteen members of the Balmer series, instead of the usual seven or eight, could be seen visually as very sharp lines. This phenomenon incidentally cannot be reconciled with the current quantum thory of the hydrogen spectrum—perhaps not an unexpected fact to those conversant with the hydrogen spectrum. No spectroscopist can in fact accept a theory which can give no hint of the origin of the so-called "secondary spectrum" of hydrogen, known to arise mainly from the atom, and, in the laboratory at least, the most important and extensive part of the spectrum. The elucidation of this spectrum is in many ways the most fundamental problem of physics, and far more fundamental than the Balmer series problem. No atomic theory as yet has begun

to interpret any of this spectrum, and several have given a theoretical account of the Balmer series.

Many of the new problems of interest, which the possession of an accurate method of intensity determination in spectra enables us to attack, are mainly of astrophysical importance. There may be variations of intensity in the Fraunhofer lines accompanying other more readily perceived solar phenomena, for example, but of more urgent importance is the need for a series of photographic registers of the intensity across the whole spectrum of a new star at different stages of its history. It has not often been possible even to determine the actual number of component radiations, in an apparent broad band with a structure, emitted from such a star, at least with any real certainty. A method which automatically sifts out such bands and gives peaks on a photograph at all the maxima of intensity in the band may well be expected to contribute greatly to the elucidation of the phenomena taking place, which must in any case be totally different from anything known by our terrestrial experience.

The only other class of phenomenon depending for its elucidation on precise measures of intensity in spectrum lines, to which I shall refer with further illustrative slides, is the variation which takes place in the spectrum from a helium tube as we recede from the cathode. The slides serve to show the considerable differences which take place in the distribution of the various series, which are all emitted most strongly at unequal distances from the cathode. One very extraordinary result, indicated clearly on the last slide, is the fact that there exists a narrow region of the tube in which the characteristic spark line λ 4686 is emitted simultaneously with the helium band spectrum, a circumstance which necessitates some readjustment of preconceived ideas.

CHINESE VEGETABLE PRODUCTS OF INTEREST.*

An instructive and valuable series of reports on Chinese products of commercial interest has been written by the United States Commercial Attaché at Peking, Mr. Julean Arnold. From Mr. Arnold's discussion on Chinese vegetable products the following particulars of some of the lesser known products are extracted.

Aniseed.—Aniseed or star anise is used in the manufacture of absinthe, anisette, cordials, and medicine. It is made from the fruit of a small evergreen tree, which grows wild in Kwangsi Province in South China. China exported in 1917 about 1500 tons of seed and about 800 tons of oil.

Apricot Kernels.—An edible variety of apricot produced in North China, is often mistaken for almonds, and serves as a splendid substitute for almonds for confections, being cheaper and similarly flavoured. Upwards of 4000 tons of apricot kernels are exported annually from North China, 80 per cent through the port of Tientsin. Three-fourths of these are the sweet and about one-fourth the bitter variety, the latter selling for about one-fourth the price of the former.

Bamboo.—The number of different varieties of bamboo found in China in over thirty. Mr. F. N. Meyer, Agricultural Explorer for the United States in China, made an extended study of the bamboo for the purpose of demonstrating its utility for introduction into the United States, and the results of his studies are available at the Department of Agriculture. Some varieties grow 35 feet in a month. A book could be written describing the manifold uses of bamboo in China. For building purposes, rafts, matting, window shades, door screens, piping, carrying poles, scaffolding, fencing, boat poles, ribs of sails, brooms, crates, cages, chop sticks, Chinese writing-brush handles, fan and umbrella frames and handles, containers, furniture, carvings, irrigation wheels, baskets, smoking pipes, combs, hairpins, pillow and mattress fillings, hats, thatching, &c., it is used extensively throughout China. It is largely employed in certain medicines. Bamboo pulp forms the chief product used in the manufacture of paper in China. Bamboo shoots are an extensive article of diet in China, and would easily find favour elsewhere for salads and as a vegetable.

Barley is grown quite extensively in North China, and particularly in Manchuria. A huskless barley is produced in Kansu.

Beans.—The sudden rise of the soya bean from a position of comparative obscurity to position of prominence in the commercial world, during a period of little more than a decade, constitutes one of the commercial wonders of the world.

In the Far East soya beans are used for the following purposes:—(1) For bean sauce or soy ("soya" is a corruption of the Japanese "shoyu"), known to the Chinese as "chiang-yu," and made by boiling the beans, adding an equal quantity of wheat or barley, and leaving the mass to ferment; a layer of salt and three times as much water as beans are afterwards put in when the liquor is pressed and strained. The sauce is clear, resembling Worcestershire sauce, and is used in a somewhat similar way. (2) For "chiang" or bean paste, eaten with fish, meat, and vegetables, and made by boiling together one part yellow beans and two parts water, grinding the mass into the shape of a pancake, and laying it in a cool place for fermentation; it is completed in two months, after which salt is added from time to time as the water evaporates. (3) For "tou-fu," or bean curd, made from green or yellow beans, by steeping the beans in water, grinding in a stone mill, passing through a strainer (which retains the epidermis of the beans), then boiling in a pot, after which the preparation is poured off into a jar, and well-diluted brine added, which, being stirred in, causes coagulation of the proteid compound legumin or vegetable casein; the mixture is then ready to be drained off and cut into blocks for sale. (4) For a form of flour extensively used for bean vermicelli, which is tasty and nutritious. (5) As a table vegetable. (6) For soups. (7) For making confectionery (in Japan). (8) For oil, as a substitute for lard, as a lubricant, as an illuminant, and to waterproof cloth, paper umbrellas, and lanterns.

Bean Products.—Bean cake is the residue after the oil has been extracted, and is extensively used throughout the Far East as a fertiliser and as cattle feed. Bean milk is produced from the small yellow soya bean. The product looks like unskimmed cow's milk, has a slight odour of beans, a fat content of 3·1, is not unpleasant to the taste, and can be delivered to customers at Changsha at two shillings per month for one pint a day.

In the west, the soya bean is little used as a foodstuff. Its principal use is for oil; a refined variety mixed with other oils serves as a salad oil or in margarine. One of the chief uses to which bean oil is put in western countries is in soap manufacture, though it is not so good for this purpose as cotton-seed oil. It is also used in the manufacture of various edible goods, toilet powders, paint oils, lubrication and lighting oils. The soya bean contains about 18 per cent oil. There are three main classes of soya beans—the yellow, the green, and the black—each with several sub-varieties. Manchuria is the centre of the soya bean and bean-oil industry, with Dairen as the chief port of export. In 1917 Dairen exported 110,000 tons of bean oil, the bulk of which went to America. The greater part of the bean cake goes to Japan.

Camphor.—The camphor of commerce is made from the camphor tree by destructive distillation. The trees, after reaching fifty years of age, are cut down, chipped, the chips boiled in vats, and the distillate collected in crystals upon straw. It is put through a refining process. Camphor is used mainly in the manufacture of celluloid smokeless powder, fireworks, and medicines. The island of Formosa,

* From the *Journal of the Royal Society of Arts*, October 31, 1919.

where the camphor is held as a Japanese Government monopoly, supplies about 75 per cent of the world's consumption. Japanese interests tried about twelve years ago to secure a monopoly of the production of camphor in Fukien Province, the main source of China's supply, but failed. As there has been no systematic replanting in China, the number of trees has continually decreased until Fukien's supplies have become nearly exhausted. Kiangsi, Szechwan, and Yunnan Provinces are said to have considerable numbers of trees, especially the inaccessible regions of south-western Yunnan. During 1917 China exported 473,000 lb. of camphor, 90 per cent of which came from Kiangsi Province.

Cassia Bark and Oil.—Cassia (*Cinnamomum cassia*) is a large and useful tree found on the borders of Kwantung and Kwangsi Provinces, and in South China generally. The bark (*cassia lignea*) is stripped off, allowed to lie for twenty-four hours, during which time it undergoes a species of fermentation, and the epidermis is easily scraped off. It dries into a quilled shape, in which it comes to market. It is smaller quilled, breaks shorter, and is less pungent and acrid than cinnamon.

Cassia oil is obtained from the leaves and the twigs by distillation, and is used in medicine. It is also used in perfumery and flavouring condiments. Cassia buds, refuse and twigs, to the extent of 6,000,000 lb. were exported during 1917.

Castor Oil.—The extensive use of aeroplanes in the war has greatly increased the demand for castor oil, which is used as a lubricant for the motors. It is also used for mixing with paints, for medicinal purposes, for cooking and illuminating purposes, and for mixing the colours for Chinese seals. The oil is extracted from the seeds by simple pressure. The crude oil is boiled with water, which separates the alkaloids, and other impurities, the water being then evaporated. In China castor beans are planted on the borders of fields to prevent animals from wandering on to them, as the beans are poisonous because of the alkaloids they contain, and the animals will not devour them. They are found quite abundantly over most of China. The oil has only recently found a place in foreign trade, and there should be good prospects for its development.

Cotton.—Estimates of China's cotton production vary considerably, but in normal years it seems to be between 1,500,000 and 2,000,000 bales of 500 lb. each. The production is increasing rapidly, and is capable of vast development. Scientific methods of planting would increase the yield per acre two or three fold, and the acreage planted could be increased almost without limit. China now produces the cheapest cotton in the world, but taxes it higher in transportation to mills in China than for export abroad. Cotton is grown throughout the Yangtze Valley and in Shantung, Shensi, Shansi, Chihli, and some of the southern Provinces. Generally, Chinese cotton is considered a short-staple product. This is especially true of that grown in the north and shipped from Tientsin. The best cotton in China is that grown in the Wei Basin in Shensi from American seed. South Tungchow, near Shanghai, also produces a very high-grade cotton.

Cotton-seed Oil, Cake, and Hulls.—Chinese cotton-seed is smaller than the American, so that the yield of oil is proportionately smaller. The Shanghai mills produce about 10,000 tons a year. The crude oil is used for cooking and illuminating purposes by the Chinese. It loses about 14 per cent in the refining process. The seeds yield about 8½ per cent crude oil, 36 per cent cake, 50 per cent hulls, ½ per cent lint, and 5 per cent dirt. The cake finds a ready market for cattle food, and the hulls are in great demand for fertiliser. China exports about 7000 tons of cotton-seed oil annually, but the home consumption is still greater.

Jujubes, Persimmons, and other Fruits.—North and West China produce excellent varieties of jujubes, which when dried are erroneously termed red dates, as well as persimmons, which when dried are erroneously called black dates. These make excellent confections for table use. China exports about 3000 tons of "black and red dates." besides producing large quantities consumed locally. The jujubes are eaten fresh, dried, stewed, or smoked. When dried they somewhat resemble a large dried date. They are boiled in sugared water, then dried. Honey is added for the best grades.

Gall nuts, or oak apples, are produced by insects on certain trees, the *Rhus javanica* and the *Rhus potaninii*, found in mountainous regions of West Hupeh, Hunan, Kweichow, Szechwan, and Kwangsi. The galls are oblong, rough, and tubular, the shell hard, brittle, and gummy, and the hollow centre has a cottony ball, the covering of the pupa. They are used to dye silks black, in tanning, and as medicine. They are reputed to furnish the finest tanning extract in the world. China exports gallnuts to the extent of about 15,000 tons a year, 75 per cent going to the United States, which now controls this trade. Hankow and Chungking are the principal ports of export.

(To be continued).

ORDER OF THE MINISTRY OF MUNITIONS.

Spirits of Turpentine.

In reference to the following Order made by the Minister of Munitions, namely, the Turpentine, &c., Control Order, dated January 25, 1918, which was by the Turpentine, &c., Control (Partial Suspension) Order, 1919, dated March 18, 1919, suspended until further notice except in so far as related to Turpentine Substitute as defined in the said Order, the Minister of Munitions hereby orders as follows:—

1. The operation of the Turpentine, &c., Control Order, 1918, is hereby suspended on and after November 1, 1919, until further notice in so far as relates to Turpentine Substitute as defined in the said Order, namely, Mineral Turpentine, White Spirit, White Oil, or any product of Petroleum under whatever name sold or known (except Motor Spirit and Benzene) capable of being used as a substitute for Spirits of Turpentine.
2. Such suspension shall not affect the previous operation of the said Order or the validity of any action taken thereunder or the liability to any penalty or punishment in respect of any contravention or failure to comply with the said Order prior to such suspension or any proceeding or remedy in respect of such penalty or punishment.
3. This Order may be cited as the Turpentine, &c., Control (Complete Suspension) Order, 1919.

PROCEEDINGS OF SOCIETIES.

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS.

Ordinary Meeting, November 5, 1919.

Dr. Samuel Rideal, President, in the Chair.

The following were elected members of the Society:—Messrs. John Haworth; Henry Turner Lea, M.Sc. (Birmingham), A.I.C.

The following papers were read:—

"*Egyptian Bricks.*" By G. Rudd Thompson, F.I.C.

The author has investigated the nature of some authentic specimens of sun-dried bricks from the neighbourhood of Pithom, one of the fortified cities of the Captivity, with a view of explaining the well-known expression "bricks

without straw," and his results go to show that "straw" did not actually enter into their composition; he also compares the analysis of the mud of the River Nile, as shown by these bricks made some 3000 years ago, with the same mud in 1912, when a remarkable similarity of composition is shown.

"*The Analysis of Brazilian Zirconium Ore.*" By A. R. Powell and W. R. Schoeller, Ph.D.

A detailed description of the analysis of the most important ore of zirconium is given. The finely-ground material is fused with sodium carbonate, the melt extracted with water, and the insoluble portion fused with bisulphate. This treatment eliminates silica, and renders all the other constituents soluble. The solution is precipitated with sodium thiosulphate, and the ignited precipitate weighed as $ZrO_2+TiO_2+Al_2O_3$. Titania and alumina are determined in this precipitate, zirconia being obtained by difference. Iron, manganese, lime, and magnesia are determined in the filtrate from the thiosulphate precipitate.

"*The Halogen Absorption of Turpentine.*" By Ethel M. Taylor.

In contradistinction to Wijs' solution a solution of IBr_3 in chloroform was found to give a distinct resting stage at a halogen absorption equal to 4Br for $C_{10}H_{16}$. This stage was reached practically instantaneously by treating turpentine with a large excess of IBr_3 and titrating back at once. The secondary reactions leading to further absorption were sufficiently slow not to interfere with the much more rapid main reaction.

MINERALOGICAL SOCIETY.

Anniversary Meeting, November 4, 1919.

Sir William P. Beale, Bart., K.C., President, in the Chair.

"*Villamaninite, a New Mineral.*" By Dr. W. R. Schoeller and A. R. Powell.

The new mineral, which occurs disseminated in black grains and plates, with a distinct cleavage and in small nodules, with a radially fibrous structure, in a crystalline dolomite near Villamanin, Cármenes district, León Province, Spain, has probably a composition corresponding to (Cu.Ni.Co.Fe) $(S.Se)_2$. Its streak is sooty black, hardness $4\frac{1}{2}$, and specific gravity 4·4 – 4·5; it is opaque.

"*Occurrence of Phenakite and Scheelite at Wheal Cock, St. Just, Cornwall.*" By Arthur Russell.

The author found good specimens of these minerals in 1914 at Wheal Cock, which is the locality whence came the crystal (undoubtedly phenakite) described by Sowerby in 1804 as argilla electrica or white tourmaline; phenakite was not known till 1833 as a distinct species.

"*New Crystal-forms on Pyrites, Calcite, and Epidote.*" By L. J. Spencer.

On pyrites the dyakis-dodecahedron (641) occurs as large well developed faces on five specimens, one of them from Traversella, Piedmont, and the others from coal shales of unknown locality. On 424 crystallised specimens of pyrites in the British Museum collection 35 crystal forms were noted. Faces of the cube are present on 76·6 per cent of the specimens, the octahedron on 62·7 per cent, the pentagonal-dodecahedron (210) on 54 7 per cent, and the dyakis-dodecahedron (321) on 36·1 per cent. As simple forms, not in combination with other forms, they are represented by 12·2, $2\frac{1}{2}$, and $\frac{1}{2}$ per cent respectively. The decomposition of specimens of pyrites in collections was discussed. Calcite, a clear scalenohedral crystal, probably from Iceland, consists of a combination of the two scalenohedra (201) and (12—0—7), both largely developed, and with an angle of only $4\frac{1}{2}^\circ$ between corresponding faces. Epidote, a crystal, probably from Ala, Piedmont, closely resembling in appearance the yellow prismatic crystals of anatase, carries a minute face (134) (Dana's orientation) in addition to twenty other crystal-forms.

"*A Curious Crystal from the Binnental.*" By Dr. G. F. Herbert Smith.

The crystal, which was found with a few loose sartorite crystals in the Trechmann collection, is twinned and tabular in habit, and shows signs of corrosion. The symmetry is peculiar, since, although a face occurs at right angles to the prism edge, it is neither a plane nor a pole of symmetry, and the crystal appears to represent a new species of sulpharsenite.

The following Officers and Members of Council were elected:—President, Sir William P. Beale, Bart., K.C. Vice-Presidents—Prof. H. L. Bowman, Mr. A. Hutchinson. Treasurer—Dr. J. W. Evans. General Secretary—Dr. G. T. Prior, F.R.S. Foreign Secretary—Prof. W. W. Watts, F.R.S. Editor of the *Journal*—Mr. L. J. Spencer. Ordinary Members of Council—Mr. H. F. Collins, Mr. J. P. de Castro, Prof. H. Hilton, Mr. Arthur Russell, Dr. A. Holmes, Miss M. W. Porter, Mr. R. H. Rastall, Sir J. J. H. Teall, F.R.S., Mr. A. F. Hallimond, Dr. F. H. Hatch, Mr. J. A. Howe, and Mr. W. Campbell Smith, M.C.

NOTICES OF BOOKS.

A Treatise on British Mineral Oil. Edited by J. Arthur Greene. London: C. Griffin and Co., Ltd., Exeter Street, Strand, W.C. 2. 1919. Pp. xi+233. Price 21s net.

This book is a collection of monographs, edited by Mr. J. A. Greene, with a foreword written by the late Sir Boverton Redwood, Bart. It deals with the production of mineral oil by the destructive distillation of shales, cannel coals, &c. The utilisation of these deposits became of paramount importance during the war, owing to the difficulty of sea transport, for bringing oil into the country.

With a view of determining the exact wealth of the country research work was commenced by the Institution of Petroleum Technologists early in 1916; shortly afterwards the Government formed the Petroleum Research Department under Sir Boverton Redwood, which brought together details of the suitable material in the country for the production of the oil and made several tests, the results of which were tabulated, when it was found that the canneloid deposits of our coalfields were on the whole the best and most utilisable sources of mineral oil.

On the invitation of Messrs. Charles Griffin and Co. the labours of these different bodies were put into a concise form, with the production of this book.

The book is divided into sections, each of which deals with a branch of the manufacture of the oil, written by practical scientists who are specialists in their own branch of the subject.

Section I., written by Mr. E. H. Cunningham Craig, B.A., F.R.S.E., F.G.S., is entitled "Raw Materials," and he gives therein a geological survey of the presence of oil shales, cannel coals, &c., to be found in the British Isles.

A great deal has been read in the Press during the last twelve months on the finding of petroleum deposits in East Anglia; conflicting opinions have been given concerning their importance. Mr. Cunningham Craig prefers to keep an open mind on the subject, for he fears that difficulties will be met with in mining operations.

The second section, written by Dr. W. R. Ormandy, D.Sc., F.C.S., deals with the retorting of bituminous materials. Before going into the actual retorting processes the author gives a brief *résumé* of the action of heat on coals, and devotes a chapter to the wasteful consumption of fuel at present going on in the British Isles. He advocates a central heating system, and contends that the heat evolved in a single fireplace as at present constructed

is in most cases sufficient to adequately warm the whole of a small house.

Dr. Ormandy's chapter on retorting deals with the different systems of retorts now in use for the distillation of coal, and he gives a very clear exposition on the advantages of the systems mentioned. From this he passes to low temperature distillation.

Section III., written by Dr. A. E. Dunstan, D.Sc., F.I.C., F.C.S., deals with the chemistry of the products of low temperature distillation as well as the nature of the raw material.

Refining of the crude oils is next dealt with by Mr. Andrew Campbell, F.C.S. The oils are refined by chemical treatment and redistillation to certain specific gravities.

Two other short monographs, by Dr. Mollwo Perkin, Ph.D., F.I.C., on "Practical Experiment Work," and the other by Mr. A. Hugh Seabrook, M.I.M.E., M.I.E.E., on the "Recovery of By-products from Coal and the Generation of Electrical Energy," with an appendix, giving the interim report of the Committee on the "Production of Oil from Cannel Coal and Allied Minerals," completes the book, which has been ably edited by Mr. Greene.

Mention may also be made of a bibliography together with a good index which are to be found at the end of the book.

The various authors deal with the subjects they have chosen in a comprehensive fashion, and the book can be thoroughly recommended.

BOOKS RECEIVED.

"The Profession of Chemistry." By Robert B. Pilcher. London: Constable and Co. 1919. Pp. xiv+199.

"The Nature of Enzyme Action." By W. M. Bayliss, D.Sc., F.R.S. Monographs on Bio-chemistry. Pp. vi+190. Longmans, Green, and Co., 39, Paternoster Row, London. 1919. Price 7s. 6d. net.

"A Text-book of Quantitative Chemical Analysis." By A. C. Cumming, O.B.E., D.Sc., F.I.C., and S. A. Kay, D.Sc. Third Edition. Pp. xv+416. Gurney and Jackson, 33, Paternoster Row, London. 1919.

NOTES.

Royal Institution.—A General Meeting of the Members of the Royal Institution was held on the 3rd inst., Sir James Crichton-Brown, Treasurer and Vice-President, in the chair. The special thanks of the Members were returned to Mr. Richard Pearce for his donation of £100 to the Fund for the Promotion of Experimental Research at Low Temperatures; to Mr. Robert Mond for his gift of Laboratory Material; and to Sir Humphry Davy Rolleston for his gift of a drawing of Sir Humphry Davy's Birthplace, and a Water Colour of his Statue in the Market Place, Penzance. The Right Hon. Lord Rayleigh, Mr. L. Griffin, Lieut.-Col. A. E. Le Rossignol, and Mr. E. Basil Wedmore were elected Members. The Chairman announced the decease of Prof. A. P. N. Franchimont, an Honorary Member of the Institution, and a resolution of condolence with the relatives was passed.

The Non Ferrous Mining Committee.—The Committee appointed by the Board of Trade to consider the question of non-ferrous mining in the United Kingdom met on October 28, 29, and 30, under the chairmanship of Mr. H. B. Betterton, M.P. Mr. J. Faull, Manager of the Tresavean Mine, near Lanner, in Cornwall, gave evidence to the effect that his Company had spent large sums of money in unwatering a mine which has been a big producer of copper ore in the past, and in developing a promising tin-ore shoot in the lower levels. They had been prevented from reaching the profit-earning stage by the intervention of the War. He outlined a scheme for further development, and suggested that the Government should assist on the principle of making advances for specific and agreed development to the extent of one half of the estimated expenditure. Mr. J. Nile, Manager of the Grenville Mines, Cornwall, stated that serious losses had been incurred during the War, and that unless financial assistance was forthcoming to enable the mine to centralise the dressing plant and to improve the system of pumping it would be impossible to continue operations. The mine made considerable profits in the years 1911-1913, but during the last three years had worked at a heavy loss. They had been further handicapped by a series of accidents at the time when men were returning from the Army, resulting in serious flooding of part of the mine. The Company had in view a large scheme of development which, in Mr. Nile's opinion, held out good prospects of success. Mr. H. E. Fern, the Receiver and Manager of Wheal Kitty in the St. Agnes District of Cornwall, expressed the opinion that this district is exceedingly rich in mineral contents, and that an amalgamation of the mines in the district, if financial assistance was forthcoming, would result in re-establishing the industry and would result in considerable diminution of working costs. He thought the industry in many cases had suffered in the past from bad management and unsound financial methods. He thought the tin-ticketing system had worked to the disadvantage of the Cornish tin-mining industry, and welcomed the signs that a change in the methods of selling tin ore was being introduced. Although he agreed with a suggestion that the nationalisation of royalties would probably do away with many of the difficulties due to the multiplicity of owners with which they now had to contend, he was not in favour of the nationalisation of the mining industry as a whole, as he did not think it would be administered by the Government as well as by individuals. He thought that representations should be made to the Commission recently set up for special consideration in the matter of railway rates, as is suggested in the case of the agricultural interest. He strongly advocated the establishment of a Department of Mines with which copies of all mining plans should be deposited, the plans being at all times available for inspection. Mr. T. E. Bennett gave evidence on the working and prospects of Kit Hill and Hingston Down mines of the Duchy of Cornwall.

Lord Moulton, in his Presidential Address at the Eighth Annual Conference of the British Commercial Gas Association, remarked upon the high honour done to him by making him the President. He said "Your Society is of a very peculiar type, and one that I should like to see repeated in many different spheres. You are one of the earliest, if not the earliest of the Societies formed by the totality of an interest for the purpose of research and to develop the usefulness of which the industry is capable. I think it shows the foresight of the gas industry that, throwing aside all questions of jealousy or special pride in individual work, they should subscribe to a Society whose business it is to bring home to every portion of the industry all the knowledge that is possessed by any part of it, and what is more, to do the tedious and unexciting, but absolutely essential, work of teaching the public the value of the industry, and how they ought to take advantage of the services it can render."

Sensational Potato Crop.—What is well described as the most sensational potato crop on record is on view this week at the National Potato Exhibition, Bingley Hall, Birmingham. Grown on one rod of ground (30¼ square yards) by a reader of the popular penny gardening weekly, "Garden Work for Amateurs," it turned the scales at well *over five and a-half hundredweight*, an astonishing total which works out, roundly, at 44½ tons per acre, quite beyond anything previously recorded. This crop is one of several hundred from similar rods of ground grown as the result of the offer by the paper named of a solid first prize of £100. The tubers are of remarkable size and excellent quality, and altogether afford a striking object

lesson of what may be accomplished in the direction of food production on even the tenth part of an ordinary allotment plot (ten rods). In the opinion of Mr. John Fraser, F.L.S., one of the judges, and the author of "The Best Potatoes, and How to Grow Them," the grower's success is due mainly to a happy combination of specially good soil and the wise selection of a recently-introduced and consequently highly-vigorous variety. This, he says, is responsible for the heavy weight of the individual tubers, and the general freedom of the crop from disease. Eight tons per acre is about the average yield of potatoes under field culture, and about one and a-half hundred-weight per rod on allotments. Twice this latter weight is quite exceptional. We understand that after the close of the Birmingham Show the crop will be placed on exhibition at the "Garden Work for Amateurs" offices in London. Country grown, it was nevertheless closely approached by that of a London amateur, whose crop, grown in the garden attached to his cottege in an inner suburb, also weighed over a quarter of a ton.

The Geological Survey of Great Britain and Museum of Practical Geology, Jermyn Street, S.W., have been transferred for administrative purposes from the Board of Education to the Department of Scientific and Industrial Research as from November 1. Correspondence with reference to the work of the Survey should be addressed as heretofore to the Director of the Survey and Museum, Jermyn Street, S.W.

Review of the Foreign Press.—A Company has been formed for the purpose of continuing the production of the *Review of the Foreign Press* which was, during the war, published under the auspices of the Government. During the publication of this paper it appeared that, apart altogether from any war time advantages, it supplied a want which had been felt for some time in political, financial, and commercial circles, and, moreover, that it provided many of the Departments of the Government with information which is useful to them no less for the purposes of peace than for those of war. In these circumstances it has been decided that as arrangements could be made with many of those who belonged to the Management and Staff of the paper when it was published by the War Office, the publication should be continued. For this purpose a small Company has been formed, the Capital of which is subscribed chiefly by leading financial and commercial houses who wished to be associated with the enterprise not only for the purpose of obtaining for themselves a regular supply of the periodical, but for the purpose of assisting the student of foreign affairs and the trading community generally to information as to what is going on in foreign countries. The paper will be edited and managed by Captain W. E. Barber, who edited it for the War Office, and he will have the assistance of many of the Staff who worked with him then. Two publications will in future be issued weekly:—On Nov. 12, the first No. of the *Economic Review*; on Nov. 14, the first No. of the *Political Review*. Subscriptions for either or both reviews should be sent direct to the Publisher, Review of the Foreign Press, Watergate House, Adelphi, W.C. 2, from whom full particulars may be obtained.

Dr. Saleeby on the Smoke Nuisance.—Speaking before the Eighth Annual Conference of the British Commercial Gas Association, in London, on October 28, Dr. C. W. Saleeby, F.R.S. (Edin.), said that though we had at last a Ministry of Health it had not been able to do very much. But it had published ideas of what it proposed to do in the future. Its latest production, he said, waving a cumbrous volume before his audience, indicated the various ways in which it was going to work to create healthy people, but there was little reference to the question of smoke. Much was said about pure water but little about pure air. That was characteristic of this country because we had been brought up in the smoke and were satisfied with it. We thought of coal as a fuel, but a chemist would tell us that coal is a treasure house of a thousand valuable things, and that to burn it is barbaric folly. One could imagine a barbarian coming along and seeing the British Museum with all its treasures and being ignorant enough to say:—"Here is something that will burn; let us make a fire." To burn crude coal and destroy thereby its latent treasures is, said Dr. Saleeby, just as short-sighted and criminal as to burn any other repository of irreplaceable wealth. We should extract from coal the dyes, and drugs, and other valuable properties which it contains and burn the residue as fuel. He advocated the increased use of gas, the spirit of coal, in place of crude coal for all domestic and industrial purposes, and urged that this question should be fully considered in dealing with the projected housing schemes.

MEETINGS FOR THE WEEK.

Tuesday, November 18.

Institution of Petroleum Technologists, 5.30. "The Conservation of Oil," by Rear-Admiral Philip Dumas.

Wednesday, November 19.

Institution of Electrical Engineers, 6. (Wireless Section). "The Design of Multiple-Stage Amplifiers using Three-Electrode Thermionic Valves," by Prof. C. L. Fortescue.

Royal Microscopical Society, 7.30.

Royal Society of Arts, 4.30. Opening Address of the 166th Session on "Science and Industry," by Sir Henry Trueman Wood, M.A.

Thursday, November 20.

Royal Society, 4.30.

Errata.—P. 214, foot of col. 1, in H. Droop Richmond's formula, for "26" read "36." Col. 2, five lines from end of article, insert inverted commas after the word "standard"; to read thus—"minimum standard."

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THE CHEMICAL NEWS

Vol. CXIX., No. 3110.

THE HARDENING OF STEEL.*

By Prof. H. C. H. CARPENTER, F.R.S.

The capacity of steel for hardening by being quenched from a bright red heat in water is the most important property possessed by any metallic substance. This property is utilised practically in the arts in a great variety of ways, and is the basis of all modern engineering work. To take two types of application only—

(1) It is utilised in the great variety of tools which are employed in modern engineering work, for machining metals and alloys to a high degree of accuracy so that they may constitute a given part of one of the thousand and one machines employed in the mechanic arts of modern civilisation, *e.g.*, the locomotive, turbine, gas engine, electro motor, &c.

(2) The razor, the balance spring of the chronometer, the knife, the needle, the pair of scissors, the surgeon's lancet, and the dentist's twist drill are instances of the utilisation of this property in the finished steel as well, and they depend upon the capacity of such material to retain its hardness in the absence of stress indefinitely at the ordinary temperatures.

Not only, however, is this property of the greatest practical import, but of the highest scientific interest, inasmuch as the search for the explanation of the capacity of steel for hardening has given rise to a large number of scientific investigations, which have done more than anything else to throw light on the constitution of steels and metallic alloys generally, and have helped to establish the modern science of metallography.

My object this evening is to trace rapidly the history of some of the salient features of this scientific work, and to bring to your notice the most modern views as to the scientific explanation of this wonderful property of steel. I must preface my remarks, however, with this warning—that within the compass of an hour's lecture it is not possible to attempt a complete exposition of the theories relating to the great variety of steel alloys that are now used in the arts, and I shall be obliged to confine my thesis to one of the simplest, albeit the best known of these materials—namely, what is called the pure carbon steel turning tool.

Let us begin by considering the manufacture of the tool itself, and afterwards the conditions under which it is put to work and what follows then.

Although even the purest iron containing only the merest trace of carbon can be hardened to some extent by quenching from a high temperature, a certain minimum percentage of carbon is necessary before the hardening is sufficiently marked to confer what may be called practical hardening properties on the steel. This minimum is about 0·7 per cent, and the cutting tools used in the arts range from this figure up to 1·5 per cent. For reasons which will be subsequently apparent, it is simplest to consider the case of a steel tool containing 0·9 per cent carbon. The operation of manufacture of such a tool is briefly as follows: In the first place, a charge designed to give the correct composition is melted down in a crucible in a furnace whose temperature ranges from 1500°—1600° C. The steel is cast from the correct temperature into a metallic mould, giving what is called an ingot, *e.g.*, a rectangular bar about 2½ inches square and 2 feet long. The ingot is subsequently forged down to a bar, say, 1¼—1 inch in diameter; it is then cut up into lengths suitable for the dimensions of the tool itself, and next it passes to the hands of the smith, who forges it by hand and fashions the tool to shape. During this operation it is of the greatest importance that the composition of the steel should be altered as little as possible by oxidation of the carbon, otherwise the tool will not harden properly or evenly. Then follows the actual hardening operation, in which the nose of the tool, as it is called, is carefully heated to a given temperature in the neighbourhood of 800° C., withdrawn either from the smith's fire, or, better still, the hardening bath, and quenched outright in a bath of cold water at the ordinary temperature.

This is an operation requiring the utmost skill. If the surface of the metal has been decarbonised in heating and scale has formed on the surface, the rapid transference of heat from the metal to the bath will not take place, imperfect hardening will result, and very likely cracks will be formed. If, however, the tool, as in the best modern practice, is heated up in a bath of fused salts, no loss of carbon takes place, and when it is removed from the bath it is covered with a thin film of fused salt. This dissolves almost instantaneously in the water, and the necessary rapid transference of heat from the metal to the water takes place. The best quenchings always have a peculiar "bite," accompanied by a dull, albeit sharp, sound, as the large bubbles of steam generated by the heat are absorbed in the surrounding water.

The steel thus hardened, although possessing the necessary hardness, is too brittle to be used as a tool. Accordingly the tempering process follows, in which it is heated to a moderate temperature depending on the work to which it is to be put. This temperature varies usually from 200°—300° C. This tempering process, while it withdraws some of the hardness produced by quenching, confers a most valuable property on the tool—namely, toughness—by means of which it stands up to its work, at any rate for a time, without cracking. Then comes the last stage, namely, the grinding of the tool on the grindstone, whereby a clean cutting edge of the required shape is produced. The tool is then ready for use,

Let us suppose that it is to be used in taking a cut from a cylindrical bar of an unhardened steel. The latter is fixed in a lathe and rotated at an appropriate speed (Fig. 1). The tool, held in a tool-holder, actuated by suitable mechanism, is gradually brought up to the end of the rotating bar and a given rate of feed maintained. For an instant there is actual contact between the cutting edge of the tool and the bar. The moment, however, that this happens a chip is formed and a shearing stress is set up, as a result of which the work falls, not on the actual edge of the tool, but on an area inside. If the metal which is being machined is ductile, it is cut away in long shavings, whose thickness depends on the feed; if, on the other hand, it is brittle, it breaks off into short chips. The effect of this friction between the two metals and the pressure of the shaving is to generate heat and to raise the temperature of the tool to a much greater extent than that of the bar which is being machined, and deterioration of the tool sets in; its hardness gradually diminishes, and *pari passu* wear of the tool itself by abrasion occurs. Eventually a stage is reached at which the cutting operation has to be discontinued, and the tool requires re-hardening or regrinding. The carbon tool of which I have just spoken cannot be used for taking the heavy cuts of which the modern alloy tools are capable, but they retain their pre-eminence even to-day in all machinery work where the highest degree of accuracy attainable is desired.

A complete theory of the action of such tools must account for both the hardening and toughening of the steel, and its gradual loss of these properties by the operations I have described.

Before attempting this, however, it may be interesting to refer briefly to the methods of hardening which chiefly occupied the attention of early workers.

The Greek alchemical manuscripts give various recipes, from which it is clear that in the early days the nature of the quenching liquid was considered to be all-important.

* A Lecture delivered at the Royal Institution, March 7, 1919.

There were certain rivers the waters of which were supposed to be specially efficacious, and Pliny mentions that the difference between waters of various rivers can be recognised by workers in steel. Many old recipes for hardening and tempering have been lost, but a number of them have come down through the ages, and from them I take the following illustrations:—The first is from a work entitled "Rechtegebranch & Alchimei" (1531), of which an English translation appeared in 1583. "Take snayles and first-drawn water of a red die, of which water, being taken in the first two monthes of harvest when it raynes, boil it with the snayles, then heate your iron red hot and quench it therein, and it shall be as hard as steele." "Ye may do the like with the blood of a man of XXX years of age and of a sanguine complexion, being of a merry nature and pleasant, . . . distilled in the middst of May." It would be interesting to know the circumstances which led to this particular experiment being first tried. These instructions may seem trivial, but a belief in the efficacy of such solutions has continued, for in a work published in 1810 ("The Laboratory or School of Arts") the artist is directed to take the root of blue lilies, infuse it in wine, and quench the steel in it; the steel will be hard. On the other hand, he is told that if he takes the juice or water of common beans and quenches iron or steel in it, it will be soft as lead. When the practice of an art is purely empirical it is liable to take fantastic forms. Even at the present day, however, there are many workshops where steel is hardened in which some quaint nostrum still holds sway. Occasionally, but not often, the use of these compounded baths was supported by theoretical views. Otto Tachen, for instance, writing of steel about the year 1666, says that steel "when it is quenched in water acquires strength because the light alcaly in the water is a true comforter of the light acid in the iron, and cutlers do strengthen it with alcaly of animals." Hence the use of snails.

Though the practice and theories in the periods I have mentioned were frequently fantastic, these early workers were quite right in attaching importance to the liquid in which the steel was to be quenched. To-day much simpler methods are used in the best modern practice. If severe quenching is required, cold water or brine is used; if a lesser degree of hardening is necessary, hot water or oil; while in many cases the processes of hardening and tempering are combined in one operation by plunging the tool in a bath of molten metal such as lead.

The rapid changes of temperature which occur when a bar of steel is quenched in a liquid from a high temperature have been studied experimentally by Le Chatelier, Benedicks, and Lejeune, and their results utilised by McCance in calculating the theoretical curve of quenching. Le Chatelier found that water gave a more rapid rate of cooling than any other liquid, and concluded that the most important property in determining the quenching power of a liquid was its specific heat. Benedicks, by means of an automatic quenching and photographically recording apparatus, obtained the most accurate results which are available as to the temperature at the centre of small round bars quenched in water. On the whole his conclusions corroborated those of Le Chatelier, but he showed that the latent heat is the most important property in determining the quenching power of a liquid under practical conditions.

The appended cooling curve (Fig. 2) deduced by McCance from Benedicks' results shows what happened when a bar of steel containing 1 per cent carbon, 2 inches long and ¼ inch in diameter, was quenched from 850° C. in water at 15° C. This curve gives the temperature at the centre of the bar at any given moment. It will be observed that it does not fall for the first fraction of a second; that the rate of fall starts slowly, then increases rapidly to a maximum, afterwards decreasing more and more slowly until it reaches the temperature of the surrounding water. From our present point of view the important thing to notice is that the time from the moment of immersion until the temperature had dropped to 500° C. was 1¼ seconds. As the diameter of the bar increases, the rate of chilling is, of course, diminished, and no doubt in the case of a rectangular turning tool of 1½-inch diameter several seconds would be required for the same drop in temperature at the centre. As McCance has pointed out, the perfect theoretical conditions for quenching are "that a specimen heated uniformly has its surface suddenly cooled to a lower temperature, and kept at that lower temperature without alteration until it has once more obtained uniformity, but at the lower temperature. The temperature of the bar changes then in a manner depending on its thermal properties and dimensions, and the rate of change thus obtained cannot be exceeded between similar temperature limits. Practical quenching depends on how far these conditions are satisfied, which really resolves itself into the simple question: How constant can the surface of the specimen be kept at the lower temperature after immersion in the liquid, and what properties must the liquid possess to fulfil this purpose best?" McCance accepts Benedicks' conclusion that vaporisation plays the most important part in the quenching power of a liquid, and the fact that water with its high latent heat of vaporisation is the best quenching liquid known accords with this view.

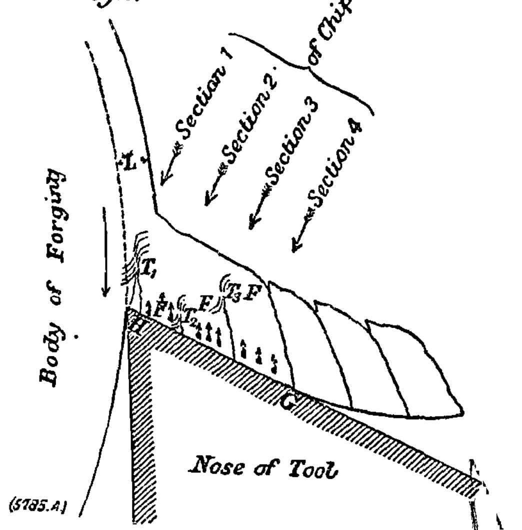
What happens when a uniformly heated bar is plunged into water at 0° C. is somewhat as follows:—The layers of water in immediate contact with the bar are rapidly heated to their boiling point, and steam is formed. This expands outwards and causes a fresh layer to come in contact with the surface, and so the process goes on. The surface of the bar alternates then between 0° C. and 100° C., the steam acting as a carrier of heat to the body of the liquid. This goes on until the supply of heat is sufficient to form steam, when the transference of heat and the cooling of the bar take place by convection only; and at this stage of the process a high conductivity in the liquid is an actual disadvantage, since it retards convection. A low viscosity is wanted to enable the steam to travel outwards with as little resistance as possible, while a high specific heat ensures that the temperature changes of the liquid are small.

We have next to consider certain fundamental properties of iron and its alloys with carbon which have been established by modern research, and without a knowledge of which any discussion of theories of hardening would be unintelligible. These properties have been for the most part investigated during the last fifty years by a small band of devoted research workers who have been the pioneers in founding the modern science of metallography.

The application of the microscope to the study of the constitution of iron and steel, regarding these materials as igneous rocks, is due to Henry Clifton Sorby, of Sheffield, who died only a few years ago, while the use of the thermo-electric pyrometer as a means of studying the changes of internal energy in the same materials is the work of a Frenchman who is still living—M. Henri le Chatelier. The methods opened up by these pioneers have proved extremely fruitful, and the results achieved by their systematic exploitation have brought certainty into a field where previously only speculation reigned. With these results it is necessary to deal briefly.

It will be convenient first to consider the evidence afforded by accurate pyrometry, although historically the microscope led the way. It is now known that the purest iron which can be obtained, containing as it does not more than three parts of impurity per 10,000, can exist in at least three different modifications, and there is every reason to believe that these modifications are a property of the iron, and not in any way due to the small amount of impurities mentioned. If the cooling of a sample of such iron from the melting point (1505° C.) is followed by means of a delicate pyrometer and potentiometer the cooling is found to be normal for about 600°. At about 900° C., however (Fig. 3), there is a sudden and large evolution of heat, which completes itself within a few degrees, and is

Fig. 1.



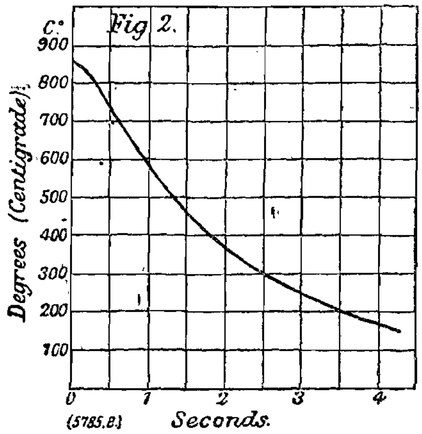
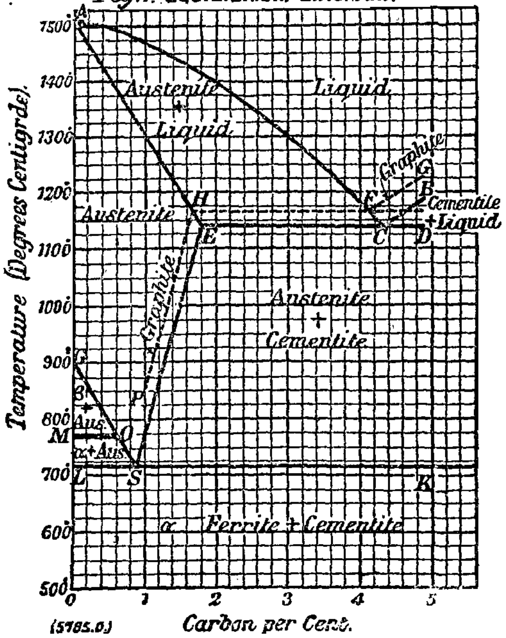


Fig. 4. EQUILIBRIUM DIAGRAM.



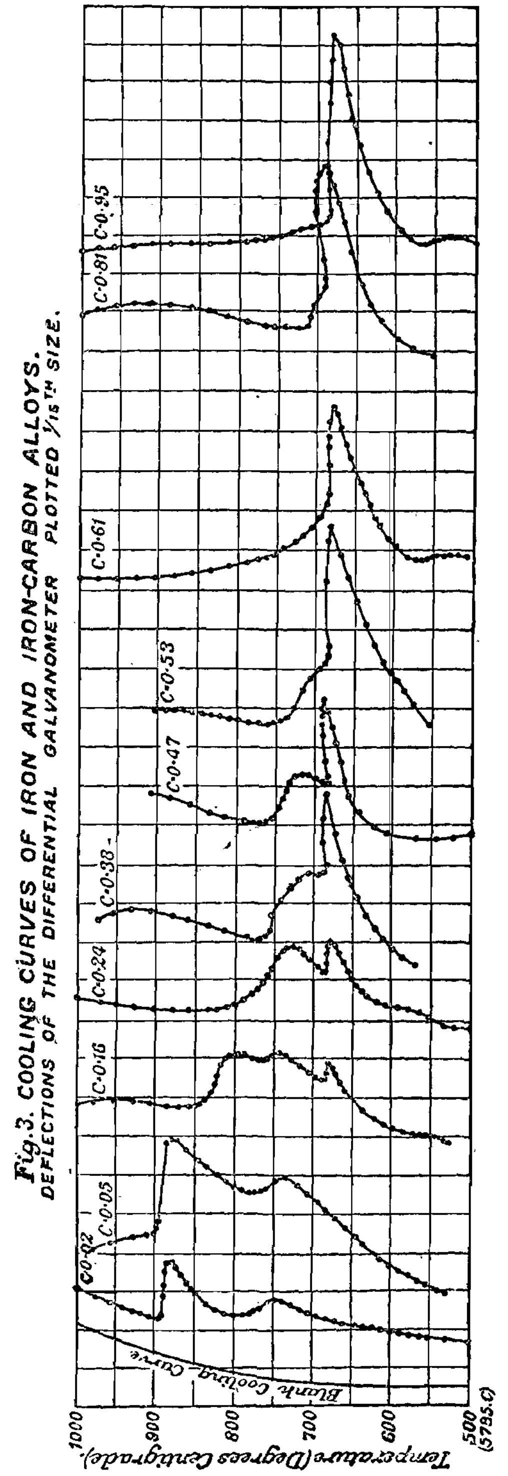


Fig. 3. COOLING CURVES OF IRON AND IRON-CARBON ALLOYS. DEFLECTIONS OF THE DIFFERENTIAL GALVANOMETER PLOTTED 1/15TH SIZE.

sufficient to arrest the fall of temperature completely for a time. After this the cooling proceeds for an interval, and then another evolution of heat occurs. This is different in character and amount from the previous one; it is markedly smaller in quantity, and is spread over a considerable temperature interval, which ranges approximately 780°—740° C. In the latter case the evolution of heat is never sufficient to arrest the fall of temperature completely. Below this point there is no further abnormality in the rate of cooling to the ordinary temperature. These two heat evolutions were rightly regarded by the early workers as marking critical points in the history of the iron ore cooling, and were called by their discoverer, the late M. Osmond, Ar_3 and Ar_2. From the freezing point down to Ar_3 the iron is known as γ, between Ar_3 and Ar_2 as β, and below Ar_2 as α. These three varieties of iron have characteristic properties, of which, from the point of view of the argument of this lecture, the following should be noted:—γ iron is completely non-magnetic, and has a considerable power of dissolving carbon, the amount of which varies with the temperature; it has also a characteristic crystalline form. β iron is also non-magnetic, but its capacity for dissolving carbon is almost nil, and it also has a characteristic crystalline form. α Iron, on the other hand, is magnetic, but in all other respects it resembles β iron very closely, and no difference in crystalline symmetry between these two varieties has yet been discovered. A considerable controversy has raged for many years now as to whether each of these varieties is to be regarded as an allotropic form of the metal. Even now this question is not yet settled, chiefly because there is as yet no consensus of opinion as to the definition of allotropy. If, however, a change in crystalline symmetry be regarded as the criterion of an allotropic change, then γ iron is certainly to be regarded as an allotrope, whereas β and α iron are to be regarded as the same variety, the only difference being that β iron is α iron which owing to rise of temperature has lost its magnetic properties. From the point of view of the hardening of steel, the important difference between these varieties of iron is that γ iron can dissolve substantial amounts of carbon, whereas β and α iron cannot, and the unique position occupied by carbon as a hardening reagent in steel is intimately connected with this difference in properties.

By adding carbon to iron and thus making steel a marked influence on the critical points of the metal is observed. Taking, for example, a steel with 0·15 per cent carbon, it is found that the temperature of the Ar_3 charge is lowered; that the Ar_2 charge is unaffected; and that a third critical point makes its appearance at about 700° C., this last-named point being of small magnitude, but completed within a very narrow range of temperature. This is known as Ar_1. Taking next an alloy with 0·35 per cent carbon, the position of Ar_3 is still further lowered, Ar_2 still remains the same, while Ar_1 appears as a much larger point. At about 0·45 per cent carbon Ar_3 has been so much lowered that it coincides with Ar_2. In other words, at this composition γ iron changes directly to α. Ar_1 is also observed, and has grown in magnitude. With the gradual addition of carbon Ar_3 and Ar_2, which have now become one point, are still further lowered, while Ar_1 increases in magnitude. Finally, at about 0·9 per cent carbon, all three points coincide at one temperature, namely, that of the Ar_1, change about 700° C. It is obvious from the foregoing that while the points Ar_3 and Ar_2 are characteristic of iron, the point Ar_1 is characteristic of iron plus carbon—namely steel.

The interpretation of the critical points thus briefly outlined has been rendered possible by the combined study of the foregoing method with the microscope, which has revealed the structural changes accompanying these heat evolutions, controlled by a consideration of the requirements of the phase rule, and elaborated into what is known us the Iron-Carbon Equilibrium diagram. This diagram (Fig. 4), whose co-ordinates are temperature and concentration, defines what, at any given temperature and concentration, are the constituents present in an iron-carbon alloy. In so far as knowledge of these is required in connection with the hardening of steel, attention may be confined to the left-hand portion of the diagram between the limits of concentration 0 to 1·5 per cent. The area A G O S E defines the limits of existence of γ iron, from which it will be seen that it can exist from 1500°—700 C., and from 0 up to 1·8 pe cent carbon. This constituent is also known as austenite. Within this area the carbon present in all steels is dissolved, and the evidence, both chemical and physical, indicates that it is combined with, as well as dissolved in, the iron as a carbide of iron. Below 700° C. only α iron is stable, and in a normally cooled steel almost the whole of the carbon is precipitated as a crystallised carbide of iron, Fe_3C. At the point S, corresponding to the composition 0·9 per cent carbon, we have the simplest case possible, for the austenite is resolved on cooling below it into a mixture of α iron and iron carbide, Fe_3C. This mixture separates in characteristic alternate plates with a laminated appearance, and is called pearlite, from its analogy to mother-of-pearl. It consists of about 86·5 per cent iron and 13·5 per cent Fe_3C, on the assumption that no carbide is dissolved in the iron. This assumption is not strictly speaking true, but the amount dissolved is so small that for practical purposes it may be neglected.

Steels on the left-hand side of S consist, below 700° C., of a mixture of iron and pearlite, whereas those to the right consist of a mixture of iron carbide and pearlite. From this diagram it will be seen why a tool steel containing 0·9 per cent carbon has been chosen for illustrating the theories of hardening. Such a steel when cooled from a high temperature has only the one critical point on cooling, namely, at S, and therefore furnishes the simplest case for discussion.

From a reference to the diagram it will be clear that if a steel tool is quenched from a red heat, say about 800° C., at the moment of quenching the constituent present is austenite. The act of quenching has for its object the rapid passage of the metal through the change point S, and the prevention of the separation of the single constituent austenite into the two constituents of pearlite.

(To be continued).

CHINESE VEGETABLE PRODUCTS OF INTEREST.*

(Concluded from p. 229).

Ginger and Galangal.—Ginger (*Zingiber officinale*) is grown in the West River and hilly districts of north-western Kwantung, throughout Szechwan, and in certain central provinces. It is eaten to a considerable extent in the green state as a condiment and a corrective. The preserved ginger comes mostly from Canton. Galangal (*Alpinia officinarum*) is sometimes mistaken for ginger proper. It belongs to the ginger family. The root is smaller than that of the ginger, being usually about two inches long and half an inch thick. It tastes like a combination of ginger and pepper. It is used as a preserve, like ginger, and also medicinally. It is cultivated in the Island of Hainan, off the Kwangtung coast. China exports about 1000 tons of galangal and about 5000 tons of ginger annually.

Ramie.—China produces grass cloth woven from ramie, pineapple, or jute fibres. The best ramie is produced in Kiangsi Province, where a considerable quantity of the cloth is woven. Szechwan Province produces large quantities of ramie, but the cloth is coarser than that produced from the superior Kiangsi fibre. Kwangtung Province also produces some good fibre. It is unfortunate that the Chinese Government has not given this industry greater attention, for it appears to possess notable possibilities.

* From the *Journal of the Royal Society of Arts*, October 31, 1919.

Kiangsi, as stated above, produces the best ramie (*Boehmeria nivea*) as well as the largest quantity. It is differentiated by the natives from hemp in that it is never irrigated. It is called a dry or mountain hemp, although the districts in which it is produced have a plentiful rainfall; the soil and the character of the land are such that the water does not inundate or stand. The seed must be sown in the autumn, and the crop can then be reaped the following year. The natives contend that the best plants are produced from the planting of the roots. The plant will last for from five to seven years. It grows to a height of 6 or 7 feet. Three cuttings a year can usually be made, although in some places only two are possible. The stalks are stripped of leaves, bundled according to size, and in some regions soaked for a few days in water. After this they are bent, and the fibre is removed by a beating and soaking process, while at the same time the mucilaginous substances in the plant are scraped off with a dull-edged knife. The process requires several days, and is all done by hand. When ready for weaving the fibre is boiled, sometimes in lime water, and beaten so as to remove the resin and gum, and make possible the separation of the fibres. This process has to be repeated a number of times. The whole process of cleaning the fibre and weaving the cloth in China is crude. The industry has not yet been commercialised. Several efforts have been made to introduce modern machinery for decortication and degumming the fibre, but apparently without success. However, with cheap labour, the present crude methods seem to produce a good fibre, and the industry assumes a position of considerable importance to the sections of the Pearl River delta in Kwangtung, Kwangsi, and Hupeh, where most of the Chinese grass is raised. But its future is still uncertain.

The ramie is bought according to quality, crop, and length. The first crop brings better prices than the second or third, and long fibres better prices than short. Because of their strong fibrous nature they are suitable for incandescent gas mantles, &c.; they produce a very fine quality of yarn suitable for light, strong underwear. For export the ramie is hydraulically pressed into bales weighing about 600 lbs., measuring between 11 and 12 cubic feet. China exports about 20,000 tons annually.

Kaoliang.—Kaoliang, or sorghum, as it is sometimes known, is one of the staple crops of North China and Manchuria. It is sown after the wheat is harvested, grows to a height of 10 feet, and is ready for cutting in September. An acre will produce from 35 to 45 bushels. It is used for human and animal food, and for making a spirituous liquor very popular with the Chinese. Three varieties are produced—white, red, and glutinous. The white is the best and is cooked like porridge. The red is best suited for wine, while the glutinous is used for dumplings, pastry, &c. The stalks are used for thatching houses, for packing and bridging, as matting for floors, and for fuel. The green blades furnish fodder for cattle.

Lichees.—The lichee is a delicious fruit raised in South China. When dried it is known on the American Pacific Coast as the "China nut." The fresh fruit is canned at Amoy, Foochow, and Canton, and considerable quantities are exported, the greater part probably going to the Chinese populations abroad.

Licorice Root occupies a prominent place in the *materia medica* of China, and in recent years has assumed a position of importance in her export trade, the Customs returns for 1917 showing an exportation of 15,000 tons, mostly from Tientsin. The licorice comes for the most part from Northern and North-Western China, growing wild in the Kokonor and Inner Mongolia districts. It is used as a sweetener and adulterant in the manufacture of porter, tobacco, and chewing gum; apart from its ordinary medicinal use.

Narcissus Bulbs.—A short distance inland from Amoy there is a bit of marshy ground which produces the bulk of the narcissus bulbs that are so highly prized by Chinese everywhere, and that for many years have been an article of export. Three million bulbs is the usual quantity produced annually for shipment, one-third of these going abroad.

Oranges.—The southern provinces of China produce many varieties of oranges, the most famous of which is the delicious sweet Swatow "honey orange," of which 6000 tons are exported annually. It is stated that eighty different varieties of oranges are produced in China.

Peanuts.—Just before the outbreak of the war the peanut industry in China had reached its highest point in its relation to the foreign export trade. The annual exports then were about 70,000 tons of shelled peanuts and about 50,000 tons of oil. More than 40 per cent of these amounts went from the port of Tsingtao, as Shantung has developed into the largest peanut-producing province in China. Seeds are sown there in May or June and harvested in October or November. The yield runs from two to four tons per acre. The province is estimated to produce more than 200,000 tons of unshelled peanuts a year. Honan and Chihli rank next in importance to Shantung in the production of this product. In 1917 China exported 25,000 tons of shelled peanuts, 7000 tons in the shell, and 30,000 tons of oil

Safflower.—Safflower (*Carthamus tinctorius*) is cultivated in Szechwan, where it is used for producing a beautiful red liquid for dyeing silks. It is used also rouge. It makes a valuable oil, and the powdered cake is a nutritious cattle food. In semi-arid regions it adapted to dry-farming methods.

Sesame.—The potentialities latent in certain products and industries in China were shown in the development of the soya bean. The extraordinary growth of the export trade in sesame seed is another instance. Up to 1897 sesame seed was scarcely mentioned as an article of export. Prior to the outbreak of the war, the exports one year reached 164,000 tons, valued at 12,000,000 taels The war, however, has so reduced tonnage and increased freight rates, that this trade (in a bulky product) has suffered severely.

Sesame is produced throughout a very large area of China, but particularly in the lower Yellow River Basin, where light, sandy soil favours its growth. It is often planted with cotton seed, the two growing up together, but the sesame is ready for harvesting before the cotton bolls are matured. The seeds are used as food, but are chiefly valued for their oil. Of the three colours, the white, the yellow, and the black sesame seed, the first-named contains the highest percentage of oil. By their native methods the Chinese get from 40 to 50 per cent of oil from the seeds. The oil is about four times as valuable as rape-seed oil; hence in China, where no laws prevent adulteration, the sesame-seed oil in the market is likely to be adulterated with rape seed oil. The seed rather than the oil was exported in large quantities to Europe, where the oil was extracted by improved processes. It is used in the manufacture of margarine, salad oils, and soaps.

Vegetable Tallow is produced from a bean or seed of a tree—the *Sapium sebiferum* or tallow tree—which grows wild in hilly sections of South, Central, and West China. The seeds (three and sometimes four to a pod) are about the size of a coffee bean. The trees are prolific bearers. The fruit, when ripe, some time in November, is spread in the sun to dry, when the pod opens and the seeds are exposed. They are covered with a greyish white substance, which is removed by steaming and then rubbing through a bamboo meshed sieve. This substance, the tallow, is melted and formed into a mould. It is reported that the seeds yield 28 per cent tallow. The seeds, after the removal of the tallow, are pressed for their oil content, which is heavy (about 40 per cent of the total). The oil is said to possess the property of turning grey hair black. It is used as an illuminant and for mixing with higher quality and higher priced vegetable oils. The refuse is valuable manure for the tobacco plant, and serves as a fertiliser generally.

In 1917, 20,200,000 lbs. of vegetable tallow were ex-

ported from China, all from Hankow. The best quality, the Kinchow, and the second quality, also white, are used in making high-grade toilet soaps and face creams. The third and fourth qualities, which are of a greenish shade, are used in cheaper soap and candle manufacture.

Varnish.—Varnish is produced in China from a tree commonly spoken of as the varnish tree, but known botanically as *Rhus vernicifera*, which is found in abundance in the mountains of Hupeh, Kweichow, and Szechwan. The varnish is taken from the tree after it is about 6 in. in diameter by tapping at intervals of from five to seven years until the tree is fifty or sixty years of age. A good-sized tree will yield from 5 to 7 lbs. of varnish. The natural colour of the crude varnish as applied is black. It is considered the most durable varnish known. One peculiarity is that it hardens only in a moist atmosphere. In China it is erroneously known among the foreign communities as "Ningpo varnish," probably because it first came into contact with foreign trade there. Many persons are poisoned when they come into even atmospheric contact with this varnish, which fact, unfortunately, reduces its trade possibilities enormously. As yet no method has been discovered whereby this poisonous quality can be counteracted. Hankow is the principal port of export for varnish. China's exports of varnish average about 1000 tons a year.

Wood oil is the oil taken from the nuts of two varieties of the *Aleurites*. While the trees are different, the oils by chemical analysis are identical. The "T'ung-yu" (*Aleurites fordii*) is essentially a hillside plant thriving in the most rocky situations and on the poorest of soils where there is a minimum of 29 in. of rainfall, although it will withstand drought as well as a few degrees of frost. The tree seldom reaches more than 25 feet in height, and is highly ornamental in foliage and flower, suggestive of impossibilities for shade-tree purposes. The fruit is a green apple-like one, about the size of a small orange, and contains from three to five seeds with about 40 per cent oil content. The trees are found for the most part in the Yangtse region west of Hankow, a large part of the trade centreing at Wanhsien. Hankow is the port of export, shipping 80 per cent of the oil. A little goes out through South China *via* Hong Kong. In 1917 Hankow shipped 36,000 tons out of a total trade of 47,000 tons, 30,000 tons of which went abroad. Buyers must safeguard themselves from adulterated oil, as it is a common native practice to add the cheaper native bean oil.

The oil has the following uses:—

In China.—(1) As a paint oil for outside purposes, excelling linseed oil in drying qualities. (2) The cruder oil—applied to native boats—paints, varnishes, and preserves in one operation. (3) With the mineral substances "t'u tsz" and "t'o-shen" added, it serves as a waterproofing varnish for silks, &c. (4) As an adulterant in lacquer varnish. (5) As an illuminant. (6) When mixed with lime and bamboo shavings, for caulking native boats. (7) The soot of wood oil produces the best quality of Chinese ink. (8) As a dressing for leather and a varnish for furniture, &c.

In America.—Chiefly for the manufacture of varnish, since it possesses the advantage of drying quickly and of making high-class varnish with cheap gums.

CANADIAN NEWS.

The Directory of Chemical Industries in Canada for the Honorary Advisory Council for Scientific and Industrial Research by the Dominion Bureau of Statistics, and issued as a part of the Census of Industry, states that there are now 634 plants manufacturing chemical products in Canada. Of these 293 are in Ontario and 161 in Quebec.

Deposits of glauber salts have been found in the vicinity of Saskatoon, province of Saskatchewan, Can. that are estimated to amount to 9,000,000 tons. This deposit, which was discovered by the Salts and Potash Co., Ltd., of Kitchener, Ont., is in the vicinity of Muskiki Lake, near Kaskakee Springs, Sask., on the Prince Albert branch of the Grand Trunk Pacific Railway. The deposit is known as a double salt, composed of sodium and magnesium, and is commonly known as crude glauber salts, or salt cake sulphate. An evaporating plant is being constructed at Kaskakee Springs, and a railway siding is being built. At present the crude material is shipped to Kitchener to be refined.

The Nova Scotia 1919 lobster season has been of a very satisfactory nature. The total catch was given as 5,852,096 lbs., valued at 1,396,946 dols. The catch was somewhat smaller than in 1918, when the quantity was 6,285,820. A much higher valuation was given for 1919, however, the 1918 catch having been valued at only 799,397 dols. In 1919 there were 1,020,864 lbs. of lobsters put up in the canneries, and 4,831,232 lbs. of live lobsters exported. In Nova Scotia the price of live lobsters was 19 cents a lb., but much higher prices were paid in Boston. Canned lobsters brought an average price of 67.8 cents per lb. The season this year lasted only from March 1 to May 31, instead of from December 15 to May 31, as in previous years.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

November 6, 1919.

A Joint Meeting of the Royal Society and the Royal Astronomical Society was held, as a "Meeting for Discussion," the subject being the results of the observations obtained at the Total Solar Eclipse on May 29, 1919.

The following summary of the opening paper was supplied:—

"*A Determination of the Deflection of Light by the Sun's Gravitational Field, from Observations made at the Total Eclipse of the Sun*, 1919, *May* 29." By Sir F. W. Dyson, F.R.S., A. S. Eddington, F.R.S., and C. Davidson.

The paper gives the results obtained in the expeditions to observe the solar eclipse of May 29, sent out by the Joint Permanent Eclipse Committee. Two expeditions were sent out—one to Principe on the West Coast of Africa, the observers being Prof. Eddington and Mr. Cottingham; the second to Sobral, in North Brazil, the observers being Dr. Crommelin and Mr. Davidson. The observers at Principe had the astrographic object-glass of the Oxford University Observatory, which they used stopped-down to 8 inches as a fixed horizontal telescope, into which the field of stars surrounding the sun was reflected from a 16-inch cœlostat. Similarly, the observers at Sobral employed the astrographic object-glass of the Royal Observatory, also stopped-down to 8 inches, and, in addition, a 4-inch lens of 19-feet focus, belonging to the Royal Irish Academy, supplied with light by an 8-inch cœlostat.

Owing to the exceptional number of bright stars in the neighbourhood of the sun, the conditions of this eclipse were specially favourable for the determination of a possible deflection of light, and the attention of the observers was concentrated on this special problem.

Happily both expeditions were successful. At Principe, in spite of cloudy weather, a few photographs were obtained, from which the deflection at the sun's limb was found to be 1·64″.

At Sobral a series of photographs with the astrographic object-glass, considered unsatisfactory on account of the distortion of the reflecting mirror, gave 0·93″ for the deflection at the sun's limb. A very good series of seven

photographs, taken with the 4-inch object-glass, gave for the deflection 1·98″, with a probable error, judged from the accordance of the results, of about 6 per cent.

The following table gives the deflections observed, compared with those predicted by Einstein's theory (which gives 1·75″ at the sun's limb):—

No. of star.	Displacement in R.A. Observed.	Calculated.	Displacement in Dec. Observed.	Calculated.
11	−0·19″	−0·22″	+0·16″	+0·02″
5	−0·29	−0·31	−0·46	−0·43
4	−0·11	−0·10	+0·83	+0·74
3	−0·20	−0·12	+1·00	+0·87
6	−0·10	+0·04	+0·57	+0·40
10	−0·08	+0·09	+0·35	+0·32
2	+0·95	+0·85	−0·27	−0·09

It is concluded that the sun's gravitational field gives the deflection predicted by Einstein's generalised theory of relativity.

PHYSICAL SOCIETY.

Ordinary Meeting, October 24, 1919.

Prof. C. H. LEES, F.R.S., President, in the Chair.

A PAPER, entitled "*The Effect of Pressure and Temperature on a Meter for Measuring the Rate of Flow of a Gas,*" was read by Dr. N. W. McLACHLAN.

The theory of an instrument for measuring the rate of flow of a gas is outlined, the effects of variation in the temperature and pressure of the gas being taken into consideration. This theory is tested experimentally for pressures varying from 1250 to 250 mm. Hg, and for temperatures from 10° C. to 100° C. It is found to be fairly accurate. The results are applied to the measurement of the rate of flow of gas on an aeroplane in the upper atmosphere, where a reduction in temperature and pressure is encountered. It is shown that the instrument reading for a certain N.T.P. volume of gas depends on the altitude, but that this volume can be obtained by using a correction factor.

DISCUSSION.

Mr. C. C. PATERSON asked if the results depended on the structure of the meter, since the paper only referred to one type.

Dr. A. GRIFFITHS suggested that some automatic method of compensating the error would be advantageous as a direct reading instrument was always desirable.

The AUTHOR, in reply, said that compensating devices were under investigation when the war came to an end. The pressure effect could be compensated by using an aneroid control to vary the area of the vane in use, but he did not see how the temperature effect could be easily corrected. As regards the structure of the meter, the diameter of the nozzle was about 3/32nds of an inch, and the rectangular vane was mounted very similarly to the moving parts of a moving coil ammeter. Either electromagnetic damping or, for laboratory purposes, ordinary fuel damping could be used.

A paper on "*A Cheap and Simple Microbalance*" was read by Capt. J. H. SHAXBY.

The instrument, devised for bacteriological use, had to be cheap and moderately robust. It consists of a long horizontal fibre joining the lower ends of two vertical beams, each pivoted very little above its centre of mass. A small weight acting at the middle of the fibre thus causes a considerable depression. This is read off by arranging a slider on a vertical millimetre scale about 2 ft. in front, so that the middle of the fibre and a second short fibre placed just behind it are in line with a "peephole" on the slider. Adjustment is provided for quickly and largely altering the sensitiveness. The deflections are converted to masses by the use of calibrating weights. The apparatus is built up from a "Meccano" set.

DISCUSSION.

Mr. C. C. PATERSON thought the instrument would have many useful applications. Had the author considered the possibility of making it a null method? A simple electro-magnetic arrangement could be employed for the purpose.

Prof. BRAGG suggested a simpler null method, which consisted in the addition of weights to attachments to the side pieces. The arrangement could be such that quite considerable weights had to be added to produce a slight disturbance of the balance.

Mr. T. SMITH asked if the author had tried reading the position of the fibre against a thick thread mounted parallel to it, instead of the inclined thread he had described. If the thick thread were brightly illuminated, and the fibre adjusted so that it appeared to bisect the width of the thread, a very accurate setting would result.

Dr. D. OWEN asked for the sensibility of the instrument shown at the meeting.

Mr. F. J. HARLOW asked for the form of the calibration curve.

Prof. LEES said the instrument reminded him of a well-known text-book method for measuring small horizontal forces, in which the force produced a small horizontal displacement of a weight suspended by a long thread. If two such suspended weights were connected by a horizontal fibre to which small loads could be attached, a micro-balance somewhat similar to Mr. Shaxby's would be obtained.

The AUTHOR, in reply, said Mr. Paterson's suggestion was interesting. He had made some attempts to convert the instrument into a null one with a magnetic control below the load. He had also tried Prof. Bragg's suggestion, by mounting weights on short horizontal arms near the fulcrums of the vertical rods. As regards sensitivity, readings could be repeated to about 1/500th of the maximum load for which the balance was adjusted. The calibration curve was nearly a straight line.

A paper on "*The Resolution of a Curve into a Number of Exponential Components*" was read by Mr. J. W. T. WALSH, M.A., M.Sc.

The paper gives a method for the resolution of a curve of the compound exponential form $B = \sum_{1}^{n} a_i e^{-\lambda_i t}$ into its components, the values of a and λ for the n different exponential terms being found from $2n$ values of B equidistant along the axis of t. A method is also given for finding the most probable values of these constants from any number ($>2n$) of observed values of B taken at irregular intervals of t.

DISCUSSION.

Mr. T. SMITH said the crux of the matter appeared to lie in the proper choice of the number of components, and this was not touched on in the paper. It was possible to come to a decision provided the observations covered a sufficiently long period. Suppose one felt justified in taking n terms, but was uncertain whether or not to go to $n+1$, a comparison of the outstanding errors when first n and then $n+1$ terms were taken would reveal whether there was any advantage in introducing the extra one.

Prof. BRAGG asked whether in the event of uncertainty as to taking n or $n+1$ terms it made much difference which was adopted. Did all the old λ's change and another one of comparable magnitude come on?

Mr. T. SMITH said the new λ might well be quite large.

Mr. E. H. RAYNER pointed out that it depended on the relative values of a, and λ whether there would be much difference in taking n or $n+1$.

Prof. LEES asked if the method worked when the a's were negative?

The AUTHOR, in reply, said that in some curves the value of n was known from *à priori* considerations, and in some other cases it was sufficient to take enough terms to fit the experimental curve well. The modifications of

the λ's in taking $n+1$ instead of n terms was not simple. In ordinary cases all the λ's would be varied, and a new one comparable with the others added. The method applied equally to negative *a*'s.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

(Chemical Section).

Ordinary Meeting, October 24, 1919.

Sir Henry A. Miers, M.A., D.Sc., F.R.S., Vice-Chancellor of the Victoria University of Manchester, in the Chair.

At the Opening Meeting of the newly-formed Chemical Section of the Society, Prof. Sir William J. Pope, M.A., D.Sc., LL.D., F.R.S., Professor of Chemistry in the University of Cambridge, gave an address on the "*Photography of Coloured Objects.*"

The ordinary photographic plate is sensitive only to blue and violet light and not to red or yellow. The plate thus receives much the same impression of a parti-coloured scene focussed npon it as we should receive on viewing the scene through deep-blue spectacles. The lively discussions concerning the claims of photography as an artistic medium which were fashionable some twenty years ago centred in reality about this limitation of sensitiveness of the ordinary photographic plate; no method of pictorial reproduction which rendered the yellow narcissus and the bright red General McArthur rose as black, whilst showing the violet as white, can be described as artistic. The prime requisite of any photographic process for the representation of parti-coloured objects is obviously that the photographic plate used should be sensitive to light other than the blue and violet; given a plate which is acted upon by light from any part of the visual spectrum many devices become applicable for the production of a satisfactory presentment in monochrome of the coloured object or for the reproduction of the actual component colours.

The first truly scientific appreciation of this principle was stated by Clerk Maxwell, the first Cavendish Professor in the University of Cambridge, who in 1861 exhibited three photographs of a tartan ribbon taken through red, green, aud blue colour-filters respectively, and pointed out that the component colours could be reproduced by superposing the three images, each illuminated by appropriately coloured light. Maxwell remarked that "by finding photographic materials more sensitive to less refrangible rays the representation of the colours of objects might be greatly improved." Long after Maxwell's day it was discovered that the ordinary photographic plate can be rendered sensitive to green, yellow, and red light by incorporating certain dyestuffs with the material of the sensitive film; previous to the war all the various methods of colour photography—the first of which was devised by Prof. Joly, of Dublin—the modern processes of photographic colour-printing, and the present-day panchromatic photographic methods for obtaining a correct rendering in monochrome of parti-coloured objects, were based upon the success which had been attained in imparting sensitiveness throughout the visual spectrum to the ordinary blue-sensitive photographic plate. By staining the plate with erythrosine it becomes sensitive to green and orange; plates so treated are termed orthochromatic. A number of dyestuffs belonging to the class of cyanine dyes discovered by Greville Williams, in 1856, are capable, however, of sensitising a photographic plate throughout the whole range of the visible spectrum. These substances are difficult to make and but little concerning their preparation and chemical behaviour has been published; their photographic applications were carefully studied by several of the large German coal-tar colour firms, and those most suitable for use in colour photography were selected and put on the market under trade names which disguised their chemical identity. At the outbreak of war the Allies were entirely dependent on Germany for these so-called photographic sensitisers; such substances had never been made in this country, and but little information as to the identity of the chief sensitisers and their methods of preparation was available. A little acquaintance with scientific photography suffices to show that this situation not only affects such aesthetic industries as those of artistic photography and colour-printing but is also vital to aeroplane photography.

Thus, a distant scene in bright sunlight is always seen to be obscured by a slight haze; this haze is enormously intensified when the scene is photographed on an ordinary blue-sensitive plate, intensified to such an extent that the photographic reproduction of the haze may blot out the whole distant view. The reason for this is that a clear atmosphere is less penetrable by blue light than by light from the less refrangible end of the spectrum. The blue-sensitive plate cannot see far into the distance because of the comparative opacity of the clear atmosphere to blue light; the eye see further because it is more sensitive to red than to blue. Obviously, if a distant scene could be photographed in red light only, the picture would reveal much more detail because of the cutting off of the haze owing to the greater penetrating power possessed by red light in a clear atmosphere.

With these considerations in mind the experimental investigation of sensitising dyestuffs was instituted in the chemical laboratories of the University of Cambridge by Dr. W. H. Mills and myself at the end of 1914. Methods for producing the ordinary sensitising dyestuffs on a technical scale were devised, and all the sensitisers used by the Allies have been prepared in the Cambridge laboratories since the German importation ceased. Our photographic air-service was non-existent at the outbreak of war; it was slowly built up until it ultimately became of great magnitude and attained a high efficiency. It started by using ordinary blue-sensitive plates, but at the date of the Armistice some 80 per cent of the plates used were red-sensitive or panchromatic plates.

The best panchromatic plate made in pre-war days possessed about one-third the sensitiveness to red as to blue light. At the present time a very rapid panchromatic plate is on the market which is much faster to red than to blue light; the rapidity of the plate to red light has been thus increased about four-fold. The advantages to be gained by the skilful use of the present highly-perfected panchromatised plates in our photographic air service, in the circumvention of camouflage colour schemes, and in the photography of distant scenes in spectroscopically pure light, are among the most important studies of the new service. The peace applications of panchromatic plates will undoubtedly multiply rapidly. A number of lantern slides were shown illustrating the points referred to above.

The chief processes at present available for the photographic reproduction of the colours of parti-coloured objects were then explained and examples of each were exhibited.

THE TECHNICAL INSPECTION ASSOCIATION.

An interesting paper was read at the Society of Arts on Friday evening, the 7th inst., before the above Association, by Prof. Baly, C.B.E., F.R.S. (of the University of Liverpool) on the subject of "*The Spectroscope in the Science of To-day,*" the chair being occupied by the President of the Association, Mr. A. H. Collinson, C.B.E., M.Inst.C.E.

Prof. Baly dwelt upon the extreme importance of the spectroscope in all research work, giving instances of its extended use by three independent groups of scientific men, viz., astronomers, chemists, and physicists, but the line of demarcation between these respective groups was so defined that very little information as to the work done

by any one group was known to either of the others. Prof. Baly urged the importance of the extended use of the spectroscope in all branches of scientific investigation, and he believed the time was approaching when it would be in daily use by the commercial exponents of applied science, as much as by those working in the realms of pure science.

The lecture was illustrated by lantern slides, and was received by the members of the Association—all practical men on the applied side of technology—with much appreciation, some of them having already made use of the spectroscope for investigations in workshop practice.

The President, in proposing a vote of thanks to the lecturer, pointed out the uses that might be made of this instrument for detection of impurities in metal, for instance, the presence of lead in brass, and asked whether it was possible to use the spectroscope for quantitative analysis.

Mr. Humphry (lately chief analyst to the Government Inspector of Steel at Sheffield), Mr. Perry (Chemist to the Inspection Department at the Royal Arsenal, Woolwich), Messrs. Wilson, Wade, and Davey all spoke congratulating the Professor on his paper, and referred to the uses that they had themselves made of the spectroscope in the work of investigation. Mr. Perry in particular pointed out that if the facts claimed by the Professor as having been definitely ascertained in regard to the composition of the nebulæ in space could be relied upon, viz., that all the known so-called "elements" were by natural processes evolved from hydrogen and helium with possibly a third not yet yet discovered on the earth and for the present named nebulium, it would appear that an epoch-making change in thought thereto was at hand, even to the extent of admitting that the dream of the old alchemists of the transmutation of metals was possible of realisation.

Prof. Baly, in his reply, admitted that there was this possibility, and in regard to the President's enquiry, stated that quantitative analysis would be possible if the spectroscope were more generally studied in the schools and laboratories of the country, and he urged that it should be one of the subjects taught to every student intending to graduate in applied science.

NORWEGIAN CHEMICAL SOCIETY, CHRISTIANIA.

October 6, 1919.

Dr. Boeckmann in the Chair.

"*The Possibility of Supplying the Farmers of Norway with Sufficient Potassium by Internal Manufacture.*" By Director A. Holtz. With the cement manufacture at Dalen, near Brevik, there will be connected in the near future Cottrell apparatus for getting the potassium out of the dust. The raw materials for the cement contains 1·5 per cent potassium, and they intend to have a production of 150,000 tons cement and 1800 to 3000 tons potassium (K_2O) per year. If all cement manufacturers in Norway would take care of the dust, they would get as much potassium as is now imported from Germany.

Sodium Carbonate Manufacture in Canada.—Glass manufacturers in Canada have been largely dependent in the past upon the United States for their supplies of glass sand and sodium carbonate. However, according to the United States Bureau of Mines Report, the new plant at Amherstburg, Ontario, Canada, at which sodium carbonate is to be made by the Solvay process, is expected to supply all of Canada's needs for soda ash. The capacity of this plant is reported to be about 120 tons per day. Some glass sand is being secured from Oneida, Ontario, but it is said to be of an inferior grade, and only suitable for the manufacture of the cheaper grades of glassware.—*Board of Trade Journal.*

NOTICES OF BOOKS.

The Simple Carbohydrates and Glucosides. By E. Frankland Armstrong, D.Sc., Ph.D. Third Edition. Pp. x+239. Longmans, Green, and Co., 39, Paternoster Row, London. 1919. Price 12s. 6d. net.

This monograph discusses the work of various investigators during the last decade, and gives a summary of the present position of our knowledge of the chemistry of the carbohydrates and glucosides. It is assumed that the reader is fully cognisant with the subject so far as it is dealt with in the ordinary text-books.

The first part of the book deals mainly with glucose as an example of the monosaccharides. It discusses fully the constitution, isomerism, derivatives, and chemical properties of this and other hexoses.

The next section deals in a similar manner with the polysaccharides.

The modern theories on the relation between configuration and properties and on the hydrolysis and synthesis of the glucosides are then explained. This is followed by an account of the occurrence and properties of the more important natural glucosides, and the preparation of those which have been synthesised whilst the work is completed by a chapter on the function of carbohydrates and glucosides in plants.

A very complete bibliography is given, the references to the various sections of the book occupying over thirty pages.

Explosives. By E. de Barry Barnett, B.Sc. (Lond.), A.I.C. London: Ballière, Tindall, and Cox, 8, Henrietta Street, Covent Garden. 1919. Pp. xvi+241. Price 12s. 6d. net.

This book, written by Mr. E. de Barry Barnett, B.Sc. (Lond.), A.I.C., is one of a series known as "Industrial Chemistry," edited by Dr. Rideal, D.Sc. (Lond.), F.I.C.

The author has divided the book into sections instead of chapters, each section dealing with a separate branch of the subject; there are altogether nine sections, including one on "Matches, Pyrophoric Alloys, and Pyrotechny," and another entitled "Sensitiveness and Stability." In this section the author outlines the general tests applied to explosives as a class, and also to special explosives.

The rest of the book is taken up in describing the modes of manufacture of each class of explosive, together with many formulæ. These formulæ are given in an abbreviated form which is current in all explosive works in Great Britain, these abbreviations being used throughout the text. At the end of each section is a small paragraph entitled "Literature," where the author gives a biblography of the subject just dealt with; this will be found useful to those requiring a more extended knowledge than the author gives.

The manufacture and use of explosives is as equally important in times of peace as war. This industry has made great strides during the war, and a book such as the one published by Messrs. Ballière, Tindall, and Cox is especially welcome so as to bring our knowledge of these matters up to date.

Organic Chemistry for Students of Medicine. By James Walker, LL.D., F.R.S. Second Edition. Pp. xi+332. Gurney and Jackson, 33, Paternoster Row, London. 1919. Price 10s. 6d. net.

During the later portion of his course, when studying the higher branches of the subject, a student of medicine is expected to possess an intimate knowledge of the occurrence, preparation, and properties of many complex organic substances. It is very difficult for him to gain more than a superficial knowledge of this subject, however,

in so short a time as is usually allotted to the study of chemistry in the ordinary medical curriculum. Bearing this in mind the author has produced a book which, although treating the subject in a systematic manner, is devoid of all matter which has no direct bearing on the subject of medicine, and which would tend to confuse the mind of the student. The book is divided into a large number of sections covering a wide field, which ranges from the simplest classes of compounds to such complex bodies as proteins, alkaloids, and dyes. Each section deals with a certain class of organic compound, and usually commences with a brief description of the general properties of the class.

These sections are then sub-divided into paragraphs in which are described substances representative of the class, all the examples being, in addition, substances which are of practical utility to the student.

The first part of the book, which is devoted to descriptions of the methods used for determining the physical constants, molecular weight, and ultimate analysis of organic compounds, is illustrated by very clear line drawings of the apparatus used.

A distinctive feature is the printing in heavy type of the names of any fresh substances as they occur in the text. This renders the book particularly easy to use for reference purposes.

We are of opinion that this excellent work will appeal strongly to all students of medicine.

Kelly's Directory of the Chemical Industries. Including Chemists and Drug Stores Chemical Manufacturers, Manufacturing Chemists, Wholesale Druggists, and all other Trades connected therewith in England, Scotland, Wales, and the principal towns in Ireland, the Channel Islands, and the Isle of Man. Kelly's Directories Ltd., 182—183, High Holborn, W.C. Price 25s. net.

The above is the fourteenth edition of this valuable and necessary directory. The proprietors have taken all possible care to make the work as accurate and as complete as possible.

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BOOKS RECEIVED.

"The Simple Carbohydrates and Glucosides." By E. Frankland Armstrong, D.Sc., Ph.D. Third Edition. Pp. x+239. Longmans, Green, and Co., 39, Paternoster Row, London. 1919. Price 12s. 6d. net.

"Iron Bacteria." By David Ellis, D.Sc., Ph.D., F.R.S.E. Pp. xix+179. London: Methuen and Co., Ltd., Essex Street, W.C. 10s. 6d. net.

"The Year-book of Wireless Telegraphy and Telephony." Pp. cxiv+1160. London: The Wireless Press, Ltd., Marconi House, Strand.

"The Paper Makers' Directory of All Nations." Pp. lvi+880. London: Dean and Son, Ltd., Fleet Street, E.C. 17s. 6d. net.

Chemistry from the Industrial Standpoint." By P. C. L. Thorne, B.A. Pp. xvi+244. London: Hodder and Stroughton, St. Paul's House, Warwick Square, E.C. 4. 4s. 6d. net.

NOTES.

Discussion on Lubrication.—The meeting of the Physical Society on November 28 next (at 5 p.m., in the Imperial College of Science, South Kensington) is to be devoted to a discussion of the subject of Lubrication. The physical characteristics of a good lubricant have long eluded definition, and it is expected that the discussion will mean at least a step towards the solution of the problem, and that it will serve to create a wider interest in the underlying theory. Amongst those who will take part are the following:—L. Archbutt, F.I.C., R. Mountford Deeley, W. B. Hardy, Sec. R.S., F. W. Lanchester, M.Inst.C.E., H. M. Martin, Principal Skinner, and T. E. Stanton, D.Sc., F.R.S. The meeting is an open one, and all who are interested are invited to attend.

Exhibition of British Manufacturers at Athens.—A cable has just been received from the Representative of the Federation of British Industries at Athens stating, that in spite of inclement weather there have been great crowds visiting the Exhibition, and that during the first seven days 15,000 paid for admission. On Sunday, October 26, the weather improved, which brought a record crowd of over 7000 people to view the Exhibition in this one day. Practically all exhibits have been sold many times over, and there has been an especial demand for machinery and textiles of all descriptions. Members of the business and trading community are arriving daily in increasing numbers from Constantinople, Smyrna, and all parts of the Balkans as well as the Levant.

The Royal Society of Arts opened its one hundred and sixty-sixth session on Wednesday last with an address on "Science and Industry" by Sir Henry Trueman Wood, M.A. An important series of lectures is announced, including three papers on "Synthetic Drugs," by J. T. Hewitt, M.A., "Some Possible Sources of Energy, by Sir Oliver Lodge, F.R.S, and others. The date and particulars will be announced weekly.

The movement in America in favour of the adoption of the Metric System of weights and measures is advancing rapidly. We have received the following particulars from San Francisco:—"Out of 58,226 petitions relating to exclusive use of metric weights and measures in U.S. America, now in the keeping of the Bureau of Standards, Department of Commerce, 57,800 petitions, or 99·27 per cent, favour this progress, and only 426, or less than 1 per cent, oppose it. This unqualified endorsement of metric standards for U.S. America is brought out in the analysis just completed at Washington by representatives of World Trade Club of petitions sent to President Wilson and America's national legislators by prominent persons and powerful commercial, manufacturing, civic, and fraternal organisations of U.S. America. Some of these petitions represent unanimous resolutions passed at conventions of organisations with thousands of members.

MEETINGS FOR THE WEEK.

Tuesday, November 25.

Institution of Civil Engineers, 5.30.

Wednesday, November 26.

Royal Society of Arts, 4.30.

Thursday, November 27.

Institution of Electrical Engineers, 6.

Friday, November 28.

Physical Society, 5.

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THE CHEMICAL NEWS

VOL. CXIX., No. 3111.

MATHEMATICAL PROOF THAT THE ATOMIC WEIGHTS ARE INTEGERS WHEN O = 16.

By HAWKSWORTH COLLINS.

FOR the following reason it is evident that the greater the atomic weight the greater is the probable error.

When the old series based upon H = 1 was altered to the present one based upon O = 16, all the at. wts. were raised in the proportion of 1·008 : 1, so that chemists admit that, when it is necessary to alter the at. wt. of H from 1 to 1·008, there are corresponding alterations required proportional to their at. wts. in all elements; consequently, the alteration assigned to Cu (*e.g.*) was 63×0·008 (= 0·5) and that assigned to U was 238×0·008 (= 1·8).

It follows that in an arrangement in which the elements are in ascending order of at. wt. those that are likely to be nearest to the actual truth come first.

Atomic Weights, 1918.

H	1·008	P	31·04
He	4·00	S	32·06
Li	6·94	Cl	35·46
Gl	9·1	K	39·10
B	11·0	A	39·88
C	12·005	Ca	40·07
N	14·01	Sc	44·1
O	16·00	Ti	48·1
F	19·0	V	51·0
Ne	20·2	Cr	52·0
Na	23·00	Mn	54·93
Mg	24·32	Fe	55·84
Al	27·1	Ni	58·68
Si	28·3	Co	58·97

The probability that H would accidentally be within 0·1 of an integer instead of within 0·2 and above 0·1, or within 0·3 and above 0·2, or within 0·4 and above 0·3, or within 0·5 and above 0·4, is 1 : 5.

The probability that He would be within 0·1 of an integer instead of being in one of the other four compartments is also 1 : 5.

Therefore the probability that this would happen by accident in the case of H and He together is $1 : 5^2$; and the probability that the same state of affairs would accidentally occur in all of the first 25 elements is $1 : 5^{25}$, with five exceptions—

$$1 : 5^{25 - \frac{5 \times 5}{4}}$$

The easiest way to see that this is correct is to notice that, when there are 20 exceptions, the probability is—

$$1 : 5^{25 - \frac{20 \times 5}{4}} = 1 : 1$$

i.e., the odds are even that only 5 of them would accidentally fall within 0·1 of a whole number. This is evidently right, because 5 would be most likely to fall within 0·1 and 5 within 0·2, and above 0·1, and so on.

But since O was taken arbitrarily as a whole number we will consider that there are 6 exceptions, and the probability that this would happen by accident is—

$$1 : 5^{25 - \frac{6 \times 5}{4}} = 1 : 5^{17\cdot 5}$$
$$= \text{One : One billion.}$$

If we take the first 35 elements up to Br with 11 exceptions—

$$1 : 5^{35 - \frac{11 \times 5}{4}} = 1 : 5^{21\cdot 25}$$

If we take the first 57 elements up to Ce with 26 exceptions,—

$$1 : 5^{57 - \frac{26 \times 5}{4}} = 1 : 5^{24\cdot 5}$$

It is no use going any further, because many of the others are quite uncertain and are obviously onlo given in round numbers.

So the probability that this state of affairs has not happened by accident, *i.e.*, that it contains a truth, is at least one billion to one. Therefore it is absolutely certain that it contains a truth, and the only possible interpretation as to what the truth is, is that the at. wts. are integers when that of O is taken as 16.

Of the first 25 elements the 5 exceptions to this matter are Mg, Si, Cl, Ne, and A. But Ne cannot be considered as it is now believed to be a mixture of two gases of at. wts. 20 and 22, and if there is so much uncertainty about the at. wt. of Ne there must also be uncertainty about A, so that there are only 3 exceptions to be considered.

These 3 elements happen to come in another generalisation as follows:—

Of the first 25 elements (not including Ne) there are only 4 whose differences from the nearest integer are greater than 0·5 per cent of those integers respectively.

The following are their at. wts. as given in 1905:—Gl, 9·1; Mg, 24·36; Si, 28·4; Cl, 35·45; and in 1918:—Gl, 9·1; Mg, 24·32; Si, 28·3; Cl, 35·46.

It is necessary to remember that when the at. wt. of an element is only given to 1 decimal place the last figure is an approximation; *e.g.*, 9·1 implies that the value lies somewhere between 9·15 and 9·05. Therefore the value 9·12 is identical under the circumstances with 9·1.

When the Int. Com. reduced the value of Si from 28·4 to 28·3 it was admitted that there were great variations in the results obtained by different experimentalists.

So the at. wts. of these 4 elements as determined experimentally may be given as:—Gl, 9·12; Mg, 24·32; Si, 28·37; Cl, 35·46: and these figures, when reduced in the same proportion, become 9·00, 24·00, 28·00, 35·00.

There are altogether no less than five peculiarities or coincidences with regard to these 4 elements, of which 1 and 4 have already been mentioned:—

1. They are the only ones of the first 25 whose at. wts. differ by more than 0·5 per cent from the nearest integers, and these 25 contain the great majority of the commoner elements, and their at. wts. are more exactly determined than others.
2. Each value is greater than the nearest whole number.
3. When the maximum valency is an even number the at. wt. approximates to an even integer, and when the max. val. is an odd number the at. wt. approximates to an odd integer.
4. If their at. wts. be reduced in the same proportion they all become whole numbers.
5. The at. wts. of Gl, Mg, and Si are especially dependent upon that of Cl.

The probability that the second coincidence would happen by accident is $1 : 2^4 = 1 : 16$, and that the third would also happen by accident is 1 : 16. Therefore the probability that the two coincidences would happen together is 1 : 256.

In order that the value for Gl might satisfy the first three peculiarities it might have been 9·1, 9·2, 9·3, or 9·4; *i.e*, 4 possibilities; Mg might have been 24·13, 24·14, 24·15, . . . 24·49; *i.e.*, 36 possibilities; Si might have been 28·2, 28·3, or 28·4; *i.e.*, 3 possibilities; Cl might have been 35·18, 35·19, 35·20, . . . 35·49; *i.e.*, 31 possibilities. The number of possible combinations of these values is 4×36×3×31 = 13392, and of these only 31 would be cases in which the four values are reducible

in the same proportion to whole numbers. Therefore the probability that one of these combinations would be hit upon by accident is $1 : \frac{13392}{31} = 1 : 432$. Therefore the probability that the four elements which have been differentiated from the others by the first coincidence would accidentally fall in with the second, third, and fourth peculiarities is $1 : 432 \times 256 = 1 : 100,000$.

Consequently, the probability that there is a truth contained in this matter is 100,000 : 1. And the only possible interpretation as to what the truth is, is that the at. wts. of these four elements are all influenced by the same error, which prevents their being given as whole numbers.

The matter now stands as follows:—It has been proved that the reason why the at. wts. approximate to whole numbers is that they really are whole numbers, and it has been shown that the apparent exceptions bear on the face of them the strongest evidence that they are not really exceptions; also the cause which has produced the apparent exceptions has been traced to the at. wt. of Cl as obtained by experiment.

It seems that there are two chief methods of calculating at. wts., viz., the method of combining weights and the method of ratio. These two methods might be the same or they might not, as will be shown by examples.

It is found that 35·46 grms. of Cl combine with 23·00 grms. of Na. Now, for the sake of argument, suppose that the 0·46 of Cl is due to condensed protyle, then the above is equivalent to finding that 35 grms. of Cl+0·46 of protyle combine with 23 of Na, so that by this method the at. wt. of Na has no error introduced into it owing to the protyle in Cl.

But by the method of ratio the error due to protyle in Cl would not be eliminated; *e.g.*, suppose it is found that the at. wts. of Cl and Br are in the ratio of 35·46 : 79·92, then chemists say that it follows that the at. wt. of Br is 79·92. But 35·46 : 79·92 is exactly the same ratio as 35 : 78·90; so that, if the 0·46 of Cl is due to protyle, the at. wt. of Br would be 78·90.

The two preceding paragraphs give a logical reason for the deduction, which has been implied, that the experimental at. wt. of Cl sometimes gives correct results and sometimes not.

It only remains now to give a reason for the at. wt. of Cl not being found experimentally to be nearly an integer. This will partly appear in the next paper.

Proof that there are Large Errors in the Higher Atomic Weights.

The periodic observation is a general rule which holds with a few exceptions throughout the whole range of elements. It was not necessary for the at. wts. to be very accurately determined in order that Mendeleeff might discover the rule; for if the at. wts. of P, S, and Cl, *e.g.*, had been 29, 31, and 33 instead of 31, 32, and 35 the rule would still have been evident.

There are two other general rules which apparently only apply to elements of at. wt. less than 60, but which require much greater accuracy in the at. wts. in order to be evident. They are as follow:—

1. The at. wts. approximate to whole numbers.
2. When the at. wt. approximates to an even integer the max. val. is even, and when the at. wt. approximates to an odd integer the max. val. is odd.

It is quite absurd that these two rules should apply only to elements which happen to have at. wt. less than 60; for this would imply that there is some general difference in the constitution and structure of those elements which happen to have at. wts. less than 60 and those above 60; but chemists cannot admit this, because they are convinced that the properties of the elements are periodic functions of their at. wts. throughout the whole range of elements, and this implies that there is no great alteration anywhere in the constitution and structure of the elements.

Therefore the cause of the absurd inapplicability of these two general rules to elements of greater at. wt. than 60 cannot lie in the actual at. wts. of those elements, but must lie in the figures that chemists give for their at. wts.

From the proof that the at. wts. of the elements, when O=16, are integers of which many are prime numbers, follows the deduction that the elements are all composed of a substance of which the at. wt. is 1. And in corroboration of this scientists have several reasons for believing that H is the fundamental substance of which all other elements are composed.

Finally, since it has been proved that the reason why the at. wt. of H is hovering round an integer is because it really is an integer, therefore the ratio 16 : 1·008 must contain an unknown source of error.

THE HARDENING OF STEEL.*

By Prof. H C. H. CARPENTER, F.R.S.

(Continued from p. 238).

COMING now to the structures of pure γ iron, γ iron containing dissolved carbon, pure β iron, and pure α iron, the following facts have to be considered:—

Pure carbonless γ iron has never yet been obtained. It is impossible by any quenching, however rapid, to bring down to the ordinary temperature the form of iron stable between A and G; the rate of change is too rapid. By means of either manganese or nickel, however, elements which lower the temperature of this transformation point below the ordinary temperature, it is possible to make alloys containing nothing but γ iron, and these possess a characteristic crystalline form. They consist mainly of polyhedral crystals which exhibit a decided tendency to twin—that is, there are certain planes in each crystal about which the crystal elements tend to rotate through an angle of 180°, thus giving rise to the characteristic twin formation easily recognisable under the microscope. As already mentioned, between β and α iron no difference in crystalline symmetry has been detected. These irons also crystallise in polyhedral crystals, which, however, exhibit no tendency to twin.

According to the equilibrium diagram, the solution of carbon in γ iron known as austenite must crystallise in the form of polyhedral crystals, since it is a solid solution, and these have the same general character as those of a pure metal. The structure of austenite, however, as obtained by quenching within the area of A G O S E, does not correspond to this theoretical deduction. Taking as an example the tool steel containing 0·9 per cent carbon, if this is quenched, say at 750° C., a faintly marked acicular structure is obtained when the specimen is examined. If the temperature of quenching be raised this structure becomes more strongly marked and the needles are decidedly larger, and even at the highest temperatures polyhedral crystals are never obtained. This acicular structure is known as martensite, and it is universally agreed that it is the characteristic structure of properly quenched steel. All the theories of the hardening of steel which have been put forward during the last forty years centre round this one question: What is martensite? If and when this question can be correctly answered it wil urnish a complete answer to the question: Why is steell hardened by quenching?

Before considering these theories two other facts must be briefly mentioned. Firstly, the carbide of iron which exists structurally free in an annealed tool steel is a very hard substance, but as it is mixed with soft α iron in the proportion of 13·5 to 86·5 the tool is comparatively soft. This carbide can be separated from the steel by appropriate solvents, which remove the iron. On the other hand, it is not possible to separate any carbide of iron from a properly quenched tool steel. When the latter is treated with dilute acids, the steel dissolves without residue and

* A Lecture delivered at the Royal Institution, March 7, 1919.

liberates a complicated mixture of hydrocarbons, both liquid and gaseous. There is therefore a fundamental difference in the form of the carbide in a quenched as compared with an annealed steel. In the former it is wholly dissolved, in the latter wholly segregated. When a hardened tool steel is softened by annealing, the carbide of iron (Fe_3C) is gradually precipitated. If the annealing is carried out at low temperatures it is precipitated in the form of ultra-microscopic particles, which are known as troostite. On raising the temperature the troostite passes into another variety known as sorbite, and at still higher temperatures well-segregated pearlite results. The gradual tempering and softening of hardened tool steel is caused by the precipitation of iron carbide in these forms together with soft α iron, and as to this no difference of opinion exists.

Secondly, all tool steels when properly quenched, and thus hardened, are magnetic. As austenite is non-magnetic, and as, so far as is known at present, the only form of iron which is magnetic is α, it follows logically that some α iron is present in hardened tools, and therefore that martensite is austenite which has undergone some change.

Up till recent times there were two chief theories of hardening, which were known as the allotropic and the carbonist. The former was mainly a French, the latter chiefly an English theory. Whatever be the verdict of history on these two theories, there can be no question that each has been justified by the volume and character of the research work to which it has led. The two schools of thought were in many respects sharply opposed, but in the light of the fuller knowledge which exists to-day it must be admitted that each has made a substantial contribution to scientific knowledge. The allotropic theory is in the main due to the late M. Osmond, who was the first to investigate the critical points of iron and steel by a delicate pyrometer. The history of the development of this theory is particularly interesting, and must be briefly reviewed if a correct perspective of its merits is to be obtained. When M. Osmond first investigated the cooling of pure iron he only detected the point Ar_3. As has been already mentioned, this is accompanied by a large evolution of heat. He called the iron above Ar_3 β, that below it α, and upon this he developed the following argument:—There are two kinds of iron, the atoms of which are respectively arranged in the molecules so as to constitute hard and soft iron, quite apart from the presence or absence of carbon. In red-hot iron the mass may be soft, but the molecules are hard; let this be called β iron. Cool such red hot pure iron, whether quickly or slowly, and it becomes soft; it passes to the α modification because there is nothing to prevent its doing so. If, however, carbon is present and the steel be rapidly chilled the following result is obtained: a certain proportion of the molecules are retained in the form in which they existed at a high temperature—namely, the β modification, which is hard—and hard steel is the result. According to this view, then, the hardness of quenched steel is due directly to iron and only indirectly to carbon.

Subsequently, when M. Osmond had perfected a more refined method of taking cooling curves, he discovered the critical point at Ar_2. As already mentioned, the evolution of heat is very much less than at Ar_3, and for some time he was unable to decide whether Ar_2 was merely the termination of Ar_3 spread over more than 100° or was an independent point. Finally, when he had shown that at Ar_2 magnetic properties appear in the iron, he decided that this point was independent of Ar_3. The logical consequence of this was that three varieties of iron had to be considered. Now comes the important point—M. Osmond changed his theory of hardening, and put forward the view that it was not the iron above Ar_3 which was hard, but the variety which existed between Ar_3 and Ar_2. The iron above Ar_3 was called γ; that between Ar_3 and Ar_2, β; and below Ar_2, α.

The difference between the two theories will now be obvious. Whereas in the former the hard form of iron was that which existed in what we know to be the γ region, in the latter it was the variety which existed in the narrow temperature range between Ar_3 and Ar_2. Hardening was thus due to an intermediate form of iron between the varieties stable at high and low temperatures. According to the new theory β iron was still supposed to be the cause of hardness, but the new β was quite different from the old one, and progress in the development of the theories of hardening would have been more rapid if it had been generally realised that the original hard β iron was, according to the more accurate knowledge revealed by later work, γ iron. The new theory presupposed the existence of all three forms of iron in a quenched tool, and according to it, the act of quenching permitted the retention of only a portion of the γ iron, while the remainder was converted into a mixture of β and α, the former conferring the hardness and the latter the toughness and magnetic properties.

This theory was enthusiastically adopted by many workers, though certain modifications of it were put forward from time to time. Whereas the Osmond theory predicated that the β iron separated in a carbonless form, the whole of the carbon being retained in the γ iron, one of the modifications put forward was that the β iron contained some dissolved carbon. The theories, however, all had this in common—that the hardness of quenched tool steel was supposed to be due to a crystalline variety of iron, namely, β, intermediate between γ and α. According to these theories, then, the special constituent present in quenched steel—namely, martensite—is due to β iron.

It is possible to test this theory to-day by fuller knowledge, and it will be sufficient to advance two considerations which seriously invalidate it. In the first place, if the equilibrium diagram be examined it will be seen that in the case of all tool steels—that is, those containing from 0·7—1·5 per cent carbon—γ iron passes directly to α and not by way of β iron at all, and it is difficult, though not impossible, to see why β iron should be formed. The usual answer made to this objection is that the diagram refers only to the stable varieties of steel, and that during quenching fugitive and unstable varieties are formed, one of which may be β iron, I cannot help thinking that this answer would never have been thought of if the equilibrium diagram had been well established before M. Osmond advanced his theory. The fact is, however, that when the allotropic theory was put forward knowledge of the diagram was very far from being as complete as it is to-day.

In the second place, this theory can be tested by experimental work published nearly six years ago by Messrs. Rosenhain and Humfrey (*Journal of the Iron and Steel Institute*, No. 1, 1913, pp. 219 268). These investigators carried out a research on the tenacity of mild steel containing 0·1 per cent carbon between 1080° and 612° C. This material contained therefore α, β, and γ iron. Strictly speaking, their research does not test hardness in the ordinarily accepted sense of the term; but it cannot be denied that determinations of tenacity do test the cohesion of a material which may be properly regarded as intimately connected with hardness. The authors found what they describe as two very well marked discontinuities in the temperature—tenacity curve, corresponding to the critical points A_3 and A_2; but whereas the discontinuity at A_3 was large that at A_2 was quite small, and their results must be regarded as negativing the view that β iron is harder than γ iron. In fact, if their curve be examined it will be found that the iron has a decidedly greater tenacity just above Ar_3 than just below it, even though a decrease in tenacity would be expected owing to the higher temperature. At 950° C., where their iron was in the γ range, the tenacity was markedly greater than at 850° C., where it was in the β range. It is very interesting that these results of Rosenhain and Humfrey fit in better with the original theory

of Osmond, which was really a γ iron theory, than with the later one.

It must also be regarded as improbable that Beta and Alpha iron, which, apart from the fact that the former is non-magnetic and the latter magnetic, only exhibit slight differences in properties, and in particular between whose crystalline forms no difference has yet been discovered, should differ so strikingly in one particular property—hardness—such as is demanded by the above theory. From the work of Sir George Beilby, which will be subsequently quoted, it would appear that two varieties of a metal possessing the same crystalline form would be likely to have the same hardness.

The carbonist theory of hardening, as the name implies, throws the chief, in fact the sole, emphasis on the function of carbon. It owes its inception to the pioneering work of Sorby, of Sheffield, who made a very careful study of the micro-structures of quenched and annealed steels. On this view the hardness of quenched steel is to be ascribed to the conversion of the pearlite, stable below Ar_1, into an amorphous constituent called hardenite, which corresponds empirically to the formula $Fe_{24}C$. According to the views of later carbonists, this hardness is the property of this solid solution, which is stated to be amorphous, and the whole of the carbon is regarded as having been trapped by quenching and retained in solid solution.

Modern research has shown that this theory is right in its assumption that the whole of the carbon is dissolved in a properly quenched steel; but in their desire to disprove the allotropic theory of hardening the exponents of this theory have gone to the unwise extreme of denying that the allotropic forms of iron have any influence on the hardness of tool steel at all. When it is remembered that iron carbide is practically insoluble in α or β iron, but is only soluble in γ iron, it is certainly unscientific to deny that γ iron has any share in the hardening process. Moreover, the theory as stated in the above form is both incomplete and contradicted by certainly one fact. It is certainly not correct to say that the constituent formed on quenching a tool steel above A_1 is amorphous, if by that is meant that it is wholly amorphous; the structure of a quenched tool steel is in the main crystalline, although, as will be subsequently suggested, some amorphous material may be present. The carbonist theory does not explain the martensitic structure of a quenched tool. If there was nothing more in the hardening process than is contained in the carbonist theory, the structure of a quenched steel should consist of polyhedral crystals, because this is the typical structure of a solid solution. Further, the hardness of quenched steel is much greater than that which can be explained merely by the retention of iron carbide in iron. Some other factor must enter in. Finally, the fact established by McCance, that on adding carbon to iron the hardness of the quenched steel increases up to 0·7 per cent carbon, and remains constant between this point and 1·18 per cent, receives no explanation from the carbonist theory, and appears to point to the conclusion which McCance has already drawn, that at any rate some of the hardening must be due to the iron itself, and that there is a definite limit to the amount of hardening that iron can stand.

These two theories mainly held the field for the best part of twenty years, and anyone who reads the history of this stimulating period in the development of metallographical thought cannot, I think, avoid the conclusion that the allotropists made a serious mistake in laying such exclusive emphasis on the function of iron, while the carbonists made an equally serious mistake by denying that iron had anything to do with hardening at all.

I pass now to consider some important research work, which, although it was not carried out on iron or steel, or indeed any other alloy of iron, has nevertheless profoundly influenced the views of metallographers with regard to the causes of the hardening of steel by quenching. This is but one instance of many which the history of scientific discovery provides, that the great advances in any particular field of knowledge are not as a rule due to workers in that field, but to those whose labours apparently have little direct relation to them. In this case I refer to the researches of Sir George Beilby on the hard and soft states in metals. Those resarches were carried out on metals which could be obtained in a very high degree of purity, and which did not possess, so far as is known, any critical points, such as those that characterise the metal iron.

The experiments were carried out for the most part with gold, silver, and copper, and there is no doubt that he made a wise choice in selecting these particular materials, which are most suitable for the particular study which he had in view. His early researches were concerned with the microscopic study of the structure and behaviour of thin films of metal, and this led him to the discovery of the nature of the operation of polishing, &c. He found that in this operation a true skin is formed over the polished surface, and that this gives unmistakable signs that it has passed through a state in which it must have possessed the perfect mobility of a liquid, although the operations were carried out at the ordinary temperature, which is several hundred degrees below the melting points of the metals in question.

The metal itself in the annealed condition is composed of crystals, but the skin formed in grinding and polishing possesses distinctive qualities which differentiate its substance very clearly from that of the unaltered substance beneath it. It is, for instance, much harder, and even when formed on the face of a crystal on which the hardness varies in different directions its hardness is the same in all directions. Since the skin can be dissolved off in stages, it was possible thus to gain an insight into the history of its formation. The surface skin can thus be investigated analytically as well as synthetically; it can be built up in stages by polishing, and it can equally easily be removed in stages; the latter operation having the advantage over the former that the method of solution lends itself to a step by step removal of great refinement and accuracy. The discovery that layers of a solid many hundreds of molecules in thickness can have the mobility of the liquid state conferred upon them by purely mechanical movement, opened up a new field of inquiry into the internal structure of metals which have been hardened by cold working. As a result of this inquiry, Sir George Beilby put forward a theory of the hard and soft states of metals, according to which hardening results from the formation at all the internal surfaces of slip or shear of mobile layers similar to those produced on the outer surface by polishing. These layers only retain their mobility for a very brief period, and then solidify in a vitreous amorphous state, thus forming a cementing material at all surfaces of slip or shear throughout the mass. The keystone of the theory is thus the instant liquefaction followed by the solidification of sheets of molecules during mechanical deformation.

It was never found possible, even by the severest deformation, to convert a crystalline into a completely amorphous metal. The resulting product was always a complex of the two varieties. In using the expression "amorphous," Sir George Beilby was careful to explain that amorphous meant non-crystalline, in the sense that the molecules are not marshalled in crystalline order and orientation, while the addition of the qualifying term vitreous narrowed the field to substances which in some degree resemble the glass-like form assumed by the silicates on cooling from the molten state. Glass is a typical amorphous substance the useful qualities of which depend entirely on the fact that it is in the non-crystalline state. As is well known, it is a very hard substance.

By careful experiments Sir George Beilby was able to show that the amorphous constituent formed by cold work is not thermally stable, but that on annealing it reverts at a given temperature to the crystalline state. Well-marked differences of properties, according to whether the metal

was wholly crystalline or a complex of vitreous-amorphous and crystalline units, were established. Thus the crystalline phase of a given metal was shown to be thermally stable but mechanically unstable, whereas the amorphous phase was mechanically stable and thermally unstable.

Subsequently, in the discussion on a paper by Prof. Edwards and myself (*Journal of the Iron and Steel Institute*, No. 1, 1914, pp. 178 180) Sir George Beilby *explained why in his view the vitreous-amorphous was* harder than the crystalline phase. By hardness was meant that the metal was more or less rigid, and that it had the power to resist larger or smaller deforming stresses without suffering permanent deformation. He proceeded to consider how this rigidity might be affected by the molecular structure of the metal. "One fundamental property of individual molecules was that they were space-filling entities which resisted the encroachment into their domain of other molecules; their bounding surfaces were probably kinetic, but they were none the less sharply defined. Another fundamental property of molecules was that they attracted each other strongly; that mutual attraction gave rise to cohesion, the quality in virtue of which the physical would continue to hold together and exist. In a mass of metal or in any other solid aggregate there was a certain available amount of cohesion which was the product of the specific cohesion of each molecule and the number of molecules present; the rigidity of any aggregate would be determined by the use to which the available cohesion was put in the actual structure. Taking the simplest of all possible forms for the molecular unit—the sphere—it was known that there were various ways in which the spheres might be built up into a homogeneous structure In the most densely packed form each sphere within the mass was in contact with twelve others; in that form there was the condition of greatest rigidity, the molecular centres of attraction being as close to each other as was possible in any unrestrained structure. But close packing of that form was not by any means common in crystal structures; indeed, it was not quite certain that it existed at all. I certainly did not by any means represent the inevitabl completion of crystalline effort. In the crystal, therefore, the structure was not necessarily, or even probably, th most rigid possible structure. The available supp y of internal cohesion was not all used up to secure max mum rigidity. In the less closely packed assemblages of spheres it could be imagined that by a small translation of the layers of molecules relatively to each other a more rigid structure might be produced. If, for example, in an assemblage of spheres in which each was only in contact with six others, a displacement occurred which brought each into contact with twelve others, it was clear that the new structure would be at least twice as rigid as the original structure. . . . It was believed that in the metals which crystallised in the regular system, such as gold, silver, copper, iron, &c., the molecules were not in closest packing; in these metals the crystalline state was one of great mechanical instability, and consequently of very small rigidity; as a result of that, disturbances by deformation caused very widespread breaking down of the crystal structure with momentary liquefaction of molecular layers and groups. If that occurred at a point below the crystallisation temperature the newly solidified portions could not receive their crystalline arrangement, and remained chilled or frozen into a more rigid type of structure, a type in which the available cohesion of the mass was more fully utilised than in the crystalline state. . . . In the case of ductile metals, flow under deforming stresses followed by resolidification left a proportion of the molecules in a condition of constraint, their freedom as vibrating units being impaired. . . . If then the available cohesion of the mass could in that way be so effectively utilised that it could put a constraint on the vibration of the individual molecules, it was not at all surprising that the molecules were so much more closely held by each other that a greater force was then required to move them over each other under deforming stresses."

In the light of investigations such as the foregoing, the hardening of steel by quenching can be viewed from a broader standpoint than was possible to earlier researchers. We know to day that metals may be hardened in four distinct ways: (1) Pure ductile metals can be hardened by cold work; (2) these metals may be hardened by being alloyed with one another or with certain non-metallic elements; such as hydrogen, nitrogen, carbon, &c.; (3) if *these mixtures are ductile, they may be further hardened* by cold working—for instance, a brass (70 copper, 30 zinc); (4) certain of these alloys can be hardened by chilling. The hardening of steel by quenching comes in this class. It is important to remember that the rapid drop in temperature which quenching produces may act in two ways:—(*a*) "It may stereotype the form of chemical combination or of structure, crystalline or non-crystalline, which is in the condition of equilibrium at the temperature a which chilling begins. (*b*) It may set up contraction strains within the cooled mass. These strains may be wholly or in part either within or beyond the elastic limits. When the strains exceed the elastic limit and permanent deformation occurs, then hardening may result as in (3)." (*Transactions of the Faraday Society*, Beilby, November, 1914).

One other fact must still be mentioned. Charpy and Grenet have shown that in iron containing very small amounts of carbon an expansion occurs on passing the Ar_3 point—that is, from γ to β iron; and further that in steels of tool-steel composition the separation of iron carbide from austenite on cooling is also associated with an expansion.

(To be continued).

ON THE SULPHITE METHOD FOR THE SEPARATION AND DETERMINATION OF GALLIUM WHEN ASSOCIATED WITH ZINC.

By LYMAN E. PORTER and PHILIP E. BROWNING.

The frequent occurrence of gallium with zinc makes the separation of these elements of especial importance. The usual method of separation consists in the precipitation of the gallium hydroxide by ammonium hydroxide in the presence of ammonium salts, the zinc remaining in solution (Lecoq de Boisbaudran, *Comptes Rendus*, 1882, xciv, 1625). This method has several disadvantages, for not only is it necessary to boil for a long time to expel the excess ammonia, in order that the precipitation may be complete, but in the process an appreciable amount of the gallium compound, the precipitate, usually adheres to the containing vessel; moreover, when extracting any considerable amount of gallium from material containing zinc, such as the leady residue from the purification of zinc or the gallium-indium alloy obtained from this residue (Browning and Uhler, and Uhler and Browning, *Am. Journ. Sci.*, 1916, xli., 351; 1916, xlii., 389), the gelatinous nature of the gallium hydroxide results in slow filtration and a tendency to include a considerable amount of the soluble zinc salts even after several reprecipitations. Various procedures have been suggested to overcome these difficulties. Dennis and Bridgeman (*Journ. Am. Chem Soc.*, 1918, xl., 1531) precipitate the zinc by the use of potassium mercuric thiocyanate, leaving the gallium in solution; the mercury is then removed by hydrogen sulphide. The gallium is separated by boiling the solution with sodium sulphite in the presence of hydrochloric acid, or by using ammonium sulphite. Care must be taken, the authors state, to have the acid concentration right, otherwise some gallium is dissolved, either by the excess of acid or by the alkali formed by the hydrolysis of the sodium sulphite.

The work described in the present article has to do with a direct application of the sulphite method to the separation of moderate amounts of zinc from gallium. It is

assumed that any indium originally present has been previously separated by sodium hydroxide, and that the greater part of the zinc has been removed by precipitating the gallium hydroxide in the presence of ammonium chloride (Lecoq de Boisbaudran, *loc. cit.*; Browning and Uhler, *loc. cit.*). The reagents used are sodium hydrogen sulphite and ammonium hydrogen sulphite, formed by saturating, respectively, with sulphur dioxide a 10 per cent solution of sodium sulphite and dilute ammonium hydroxide (1 : 4).

Preliminary experiments showed that 0·0002 grm., or even less, of gallium can be precipitated in 5 cc. of solution by boiling with a drop or two of either of these reagents. Similar experiments on solutions containing zinc showed no precipitation even after boiling ten minutes, although it may be precipitated from neutral solutions by neutral sodium sulphite. To test the completeness of the gallium precipitation, a study was made of the delicacy of the potassium ferrocyanide test (Lecoq de Boisbaudran, *Comptes Rendus*, 1884, xcix., 526), with a view to using it to detect gallium in the filtrate after the sulphite precipitation. In hydrochloric acid solution as small an amount as 0·0001 grm. of gallium in 5 cc. of solution can be detected by the ferrocyanide (Browning and Porter, *Am. Journ. Sci.*, 1917, xliv., 221). It was found, however, that if 0·002 grm. of gallium in 5 cc. of solution is treated with ammonium hydrogen sulphite in the cold no precipitate forms upon the addition of the ferrocyanide, nor does it come down on long standing. The addition of an excess of hydrochloric acid to this solution, however, causes precipitation. By the use of smaller amounts of gallium it was found that the delicacy of the test is not interfered with by the sulphite, provided that sufficient hydrochloric acid or other strong acid is present. This constitutes a difference between the behaviour of gallium and that of zinc, because the latter may be precipitated as the ferrocyanide from a solution containing sulphite, even in the absence of strong acid.

A series of precipitations of gallium was made from neutral or slightly acid solutions by boiling them with ammonium hydrogen sulphite. Amounts of gallium ranging from 0·0005 grm. to 0·005 grm. calculated as the metal were used. The filtrates from the precipitations were treated with hydrochloric acid and potassium ferrocyanide. Negative results proved the completeness of the precipitation.

The following procedure for the qualitative detection and separation of gallium and zinc was tried successfully on unknown solutions. The results are given in Table I. The neutral or slightly acid solution, about 5 cc., is boiled for two minutes with sodium hydrogen sulphite. A precipitate, indicating gallium, is filtered off after it settles. Hydrochloric acid is then added to the filtrate, followed by potassium ferrocyanide. A precipitate here shows the presence of zinc. Similar results were obtained by substituting ammonium hydrogen sulphite for the sodium salt. In Table I., Expts. 11 to 13 are significant in that the failure to get a test with the ferrocyanide gives additional evidence that the precipitation of gallium is complete.

This method lends itself well also to the quantitative estimation of gallium in the presence of zinc, on account of the granular form of the precipitate. The gallium is conveniently precipitated from 200 cc. of solution, which is neutral or slightly acid. After the addition of 4 or 5 cc. of ammonium hydrogen sulphite the solution is heated to boiling for from three to five minutes. At the end of this time the precipitate of gallium is in distinctly granular form and settles readily. The supernatant liquid is decanted through a filter-paper. The precipitate left in the beaker is dissolved by the addition of a few drops of hydrochloric acid and 200 cc. of water is added. The gallium is reprecipitated as before, and the precipitate is filtered off upon the original filter-paper, ignited, and weighed as Ga_2O_3. It was found that if the gallium is not reprecipitated when zinc is present a somewhat high result is obtained, but this is obviated by a single reprecipitation.

Table I.—*Qualitative Detection of Gallium and Zinc.*

Expt.	Taken (grm.).	Found.	
1.	Ga 0·0001	Ga present (*a*)	Zn absent
2.	Ga 0·0002, Zn 0·0015	Ga present	Zn present
3.	Zn 0·001	Ga absent	Zn present
4.	Ga 0·0002, Zn 0·0003	Ga present	Zn present
5.	Ga 0·0003..	Ga present	Zn absent
6.	Zn 0·0002..	Ga absent	Zn present
7.	Ga 0·0002..	Ga present	Zn absent
8.	Zn 0·0005..	Ga absent	Zn present
9.	Distilled water.. ..	Ga absent	Zn absent
10.	Ga 0·0003..	Ga present	Zn absent
11.	Ga 0·005	Ga present	Zn absent
12.	Ga 0·0025..	Ga present	Zn absent
13.	Ga 0·005	Ga present	Zn absent

(*a*) Doubtful.

Expts. 9 and 10, Table II., are of special interest, because in the former the gallium was reprecipitated three times, and in the latter twice, the results showing that this procedure does not result in any loss of gallium.

Table II.—*Quantitative Estimation of Gallium Precipitated by Ammonium Acid Sulphite.*

Expt.	Amount $ZnCl_2$ taken (grm.).	Amount Ga_2O_3 taken (grm.).	Amount Ga_2O_3 found (grm.).	Error (grm.).
1.	0	0·0202	0·0203	0·0001 +
2.	0	0·0236	0·0235	0·0001 −
3.	0·1	0·0202	0·0199	0·0003 −
4.	0·1	0·0202	0·0203	0·0001 +
5.	0·35	0·0151	0·0149	0·0002 −
6.	0·3	0·0202	0·0201	0·0001 −
7.	0·1	0·0236	0·0236	0·0000 ±
8.	0·1	0·0236	0·0239	0·0003 +
9.	0	0·0472	0·0471	0·0001 −
10.	0	0·0236	0·0234	0·0002 −

—*Journal of the American Chemical Society*, xli., No. 10.

USE OF ELECTRICITY IN AGRICULTURE.*

With Special Reference to its Development in Germany.

By JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

(Continued from p. 206).

Overhead Line.—The high-tension overhead transmission line employed for distributing electric power to agricultural districts is of the usual type, the only special feature being the method of connecting the high-tension line to the portable transformer wagons. This method is shown in Fig. 1, from which it will be seen that some of the transmission poles have mounted on them a special connecting device. This device is provided with copper supporting hooks for the portable connecting cables, and is made either with or without a switch.

(*a*) In the arrangement without a switch the copper hooks are insulated and supported from an angle iron fastened to the pole.

(*b*) In the arrangement with a switch the copper hooks are insulated and carried on a shaft parallel to the angle iron. In this case they are provided with horn-shaped extensions which, when the switch is closed, make contact with somewhat similar horn-shaped fixed contacts which are insulated and supported from the angle iron fastened to the pole. These horns work in a similar way to the usual horn-type switches used for high-tension

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plant. A switch rod is provided as a part of the transformer wagon equipment, to enable the switch to be opened and closed.

Transformers.—For long distances, to avoid large losses in distribution and to enable conductors of small cross section to be used, it is essential, as has been pointed out, to transmit electric energy at a high voltage, and this makes it necessary to reduce the high voltage at the using point to a safe working voltage by means of transformers. These transformers may be either permanently fixed or portable, depending on the requirements.

Permanent transformers are employed when a supply of electricity is required for a sufficient time to justify their installation. In this country and in Germany permanent transformers are placed either in special buildings or in rooms set aside for their accommodation. In Canada and the United States, on the other hand, transformers especially designed for the purpose are frequently placed in the open air without any protection other than a rail or guard, and small transformers, similarly, are found mounted on the transmission poles themselves. These arrangements have the great merit of cheapness, and deserve more consideration from power-station engineers here than they have yet received.

The portable transformers are generally carried in wagons, and a typical German design is shown in Figs. 1 and 2. These wagons are substantially built with wooden wheels, the front wheels being, for the large sized transformers, about 800 mm. diameter and 120 mm. wide, and the back wheels 1200 mm. diameter and 150 mm. wide. The large diameter of back wheel enables the wagon with its transformers to be moved without difficulty over bad roads and in fields, &c., and to enable these to be fitted the back axle is bent downwards at the centre. Strong springs are provided for both axles to protect the transformer from vibration, and a strong hand brake, the operating handle for which may be seen in Fig. 2, is also fitted. These portable transformer wagons are employed in great numbers for pressures from 5000 to 30,000 volts on the high-tension side and capacities varying from 25 to 100 k.v.a., for agricultural and other purposes. A usual size for such a transformer for agricultural work is 70 k.v.a., and the working weight of the wagon complete with such a transformer is about 3000 kgrms. Such a wagon can be hauled along level roads without difficulty by two fairly strong horses. A driver's seat is not provided as the drivers are not encouraged to drive quickly. The interior of the wagon is divided into two compartments by means of a partition, both compartments being provided with a suitable locked door to prevent unauthorised access.

The high-tension compartment contains the transformer, usually of the standard oil-immersed type and designed to withstand the strains which the wagon receives in rough agricultural work. Depending on the size and voltage of the transformer and on the rules of the power supply authorities, either fuses or an automatic oil switch are provided as a protection on the high-tension side so as to open the circuit on overloads. For voltages about 500 volts, choking coils are also used to prevent damage to the windings from excessive voltage, as for instance in the case of lightning.

The low-tension compartment contains fuses, a watthour meter, and a cable connecting box, and the low-tension apparatus is in duplicate when the transformer is arranged for two different low-tension voltages, to enable it, for instance, to be used for ploughing and threshing, for which frequently different voltages are employed.

The connection between the high-tension side of the transformer and the transmission line is made at one of the poles, which carries a connecting device, such as has already been described. For connecting the transformer to this device three bare or insulated conductors are provided, fitted with rings at one end. These rings are placed, by means of the insulated switch rod already referred to, on the hooks on the pole device, the other end of the conductors being attached to terminals permanently connected to the transformer and carried on insulators on the roof of the wagon.

The length of portable conductor may vary from three to six metres, to suit different heights of pole and to keep the wagon, when necessary, a few metres away from the pole.

In exceptional cases short auxiliary high-tension conductors carried on poles may be necessary to connect the transformer to the high-tension line, but the cost of such additional conductors need not be excessive.

The conductors are only attached or removed when there is no current passing, and both insulated rod and the wagon are provided with an earthing device.

The portable electric transformer has a specially important part to play in agriculture, and in view of its advantages many of the larger central stations in Germany are providing these transformers in increasing numbers for supplying on hire.

Portable Cable Creels.—A flexible cable is necessary to connect each portable motor, or the winding wagons in the case of electric ploughing, with the low-tension side of the transformer. Each small motor is provided with a short length of such cable, ending in a suitable connector. This cable is shown lying loose in Figs. 5 and 6. The larger motors, carried on a motor wagon, are sometimes provided with a cable drum, Fig. 8, and this cable drum is capable of carrying up to 300 metres of flexible cable: Additional lengths of cable must be carried on a portable cable creel carried on a special wagon (Fig. 4). Where the distances to be covered are greater than 300 metres, separate lengths of cable are used, and these are provided with plugs and receptacles so that they can be easily joined together. Each receptacle is fitted with a switch so that it may not be possible to switch on the current until the cables are properly connected. The total length of cable used may be as much as 1000 metres, and its division into separate lengths of 300 metres is made so that only the necessary length of cable is connected in each case to suit the length of land to be ploughed, and in this way unnecessary waste of labour is avoided and also the number of workers is reduced.

The transformer wagon itself, as already mentioned, carries a low-tension cable drum and 300 metres of cable, when it has not to carry choking coils for protection in extra high-tension work. The insulation and outer covering of the flexible cable are in all cases such as to withstand the rough usage received in ploughing and similar work based on practical experience.

(The Illustrations will appear in a later issue).

(To be continued).

PRODUCTION OF ARTIFICIAL ABRASIVES.

Under the auspices of the Society of Chemical Industry (Birmingham and Midland Section), a meeting, also attended by the members of the Birmingham Metallurgical Society, was held on Thursday November 13, at the University of Birmingham, when Mr. C. J. Brockbank, of Thorold, Ontario, read a paper on "*Production of Artificial Abrasives in the Electric Furnace.*" Mr. L. P. Wilson, Coventry, presided.

Artificial abrasives require for their production, said Mr. Brockbank, large quantities of electrical energy, such as can be furnished cheaply by the enormous water-power developments of Canada, the United States, and similar countries abroad. Due to this natural advantage there have developed in Canada several plants of large size devoted entirely to the manufacture of artificial grinding materials called by various trade names, but consisting of two groups, one silicon carbide and the other aluminous abrasive, or artificial corundum. The refractory by-products produced are also of great importance, and have contributed very materially to increased efficiency in the

operation of many types of furnaces. The first artificial abrasive was discovered by Dr. Acheson in 1890, while endeavouring to crystallise carbon by dissolving in melted silicate of alumina fused by a small electric arc in an iron pot. His ignorance of chemistry led to one of the most remarkable discoveries in the electro-metallurgical field, and formed the foundation of what is to-day one of the most important industries in the world. Dr. Acheson conceiving that the blue crystals resulting from his experiments must be a combination of carbon and alumina, and ignorant of their real chemical composition, named the material carborundum.

Silicon carbide is not a universal abrasive, in that it cannot be used on all classes of grinding. It is suitable and highly efficient in the grinding of brittle materials such as cast iron, marble, mother-of-pearl, &c., and the finishing of leather. The physical properties of silicon carbide render it unsuitable for producing the fine smooth finish required in steel grinding. It is intensely hard (the next hardest material to the diamond), and very brittle. During grinding the edges of the individual grains are constantly fracturing, exposing fresh cutting edges which score deeply into a tough material such as steel. The discovery that aluminous ores, such as bauxite and emery could be electrically smelted with coke, and commercially pure crystallised artificial corundum obtained therefrom, completed the requirements of the abrasive field, and rapidly forced natural emery into the background, except for a few restricted operations such as glass polishing.

Silicon carbide is formed by the reaction at high temperatures of silica and carbon. In practice it is found necessary to add varying amounts of sawdust and sodium chloride; the former is to maintain porosity, so that the large volumes of carbon monoxide may escape without causing blowholes at local spots in the furnace; the salt is used to assist in the elimination of the impurities present in the coke and sand as chloride. A typical furnace mixture when all new materials are used is:—Petroleum coke, 1500 lbs.; white sand, 2520 lbs.; sawdust, 300 lbs. (18 c.f.); and salt, 40 lbs. A considerable proportion of the mixture used in a furnace is not converted into silicon carbide, acting merely as a heat insulating blanket, and this material will ordinarily be returned to the mixing department. Petroleum coke is the carbon residue left in the stills when distilling crude oils. It is the only form of carbon that can be used satisfactorily for producing the highest grade of silicon carbide. This does not appear to be due altogether to its purity, since good silicon carbide cannot be made from lamp-black, but is in some way due to the readiness with which this form of carbon is converted into graphite by the agency of heat. Charcoal is readily changed to graphite, and similarly will make excellent silicon carbide. Silicon carbide furnaces are built in sizes varying from 1000 h.p. capacity to 3000 h.p. capacity. A furnace of less than 1000 h.p. size cannot be operated economically. A 3000 h.p. furnace will produce approximately 7 per cent more silicon carbide per unit of power input than a 1000 h.p. furnace, although the advantage is somewhat offset by the fact that the quality from the largest size is not so good. A 1000 h.p. electric furnace is 20 feet long between the heads carrying the electrodes and 5 or 6 feet wide inside. The heads carrying the electrodes are 40 inches thick, and two electrodes are used for each terminal, made from graphite 10 inches diameter and 48 inches long. The method of loading the furnace is as follows:—The furnace is charged with mixture slightly above the level of the electrodes, and a trench formed in this mixture 36 inches wide and 10 inches deep, which is filled with about 1200 lbs. of graphite powder. This forms the resistor core, and conducts the current from one terminal to the other. Mixture is then piled on this core and the furnace is ready to operate. There is considerable shrinkage during the run, the level gradually falling below the side walls of the furnace. The side walls must not be removed till at least twenty-four hours after a furnace has been disconnected, otherwise the product is liable to be injured by oxidation.

As to the finishing of the silicon, it was explained by Mr. Brockbank that the crystalline silicon carbide after removal from the furnace is crushed in a pan mill, then it is treated successfully with a sulphuric acid and caustic soda bath. This removes the surface impurities from the grain, consisting of graphite, silicon, silicides of iron (mainly SiF_2), and silicide of aluminium. It is then washed and dried in a rotatory dryer, and passed over screens which separate the grains into various sizes from 1/6 inch mesh to 1/220 inch; finer sizes are graded by hydrostatic methods. The material forms the pure product used by the wheel manufacturer for making abrasive wheels.

Regarding aluminous abrasives or artificial corundum, these are manufactured by smelting a mixture of bauxite and coke in an arc furnace; the impurities, mainly silica and iron oxide, are reduced and settle to the bottom of the furnace, and the fused alumina is recovered in the form of a large pig or ingot weighing four to five tons. A typical furnace mixture is—calcined bauxite, 1750 lbs.; coke, 100 lbs; iron borings, 350 lbs. The furnace is started by placing a layer of mixture in the furnace about 1 foot deep, and laying a train of graphite powder from an electrode to the other on the top of this. As soon as a small path of molten ore is formed this carries the current, and more mixture is charged into the furnace as required. These furnaces operate at about 100 volts, and require 550 kw. Reduction must not be carried too far, otherwise the abrasive will be too pure and brittle. The presence of 1 or 2 per cent of iron oxide, silica, and titanium dioxide increase the toughness of the product. The metallic residue recovered will contain from 10 per cent to 15 per cent of silicon. Sufficient iron borings are added to the mixture to keep the silicon content of the alloy below 15 per cent; otherwise the material would be too weakly magnetic to be separated from the crushed corundum. Power is a comparatively small proportion of the total manufacturing cost of artificial corundum, and it would therefore appear to be quite practicable that aluminous abrasives should be manufactured in England at a cost that would compete with the foreign product.

A brief discussion followed.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, November 13, 1919.

Sir J. J. Thomson, O.M., President, in the Chair.

The following papers were read:—

"*The Genesis of Œdema in Beriberi.*" By Lieut.-Col. R. McCarrison.

Conclusions previously reached by physiological methods of adrenalin estimation are confirmed by chemical methods.

Deficiency of certain accessory food factors gives rise to a greatly increased production of adrenalin.

Whatever the function of adrenal medulla may be, excessive production of adrenalin, under conditions of "vitaminic" deficiency, is concerned with causation of œdema.

"*The Microscopical Features of Mechanical Strains in Timber and the Bearing of these on the Structure of the Cell-wall in Plants.*" By W. Robinson.

The gross and microscopic characteristics of failure in compression are described for spruce, ash, and pitch pine. It is shown that failure is initiated by the development of microscopic planes of slipping in the cell-walls of the wood. The appearance of the slip planes in the cell-walls is accompanied by profound changes in the behaviour of

the latter towards many stains and reagents. These changes are discussed in relation to their possible bearing on the process of lignification of cell-walls.

In addition to compression, the failures in longitudinal tension and longitudinal shearing are described. An attempt is made to correlate the microscopic effects of these three forms of stress with the visible structure of the cell-walls and with the double refraction of these. There are important differences in the behaviour of the cell-walls of wood towards tensile and compressive stresses respectively. This mechanical anisotropy of the cell-walls of wood is discussed in relation to hypotheses of cell-wall structure.

While it is pointed out that the facts derived from the study of failure in timber are not wholly inconsistent with the micellar hypothesis of Naegeli, an alternative hypothesis of cell-wall structure is proposed. In this hypothesis it is suggested that the mechanical anisotropy, as well as the optical properties and the visible structure of cell-walls may be explained as the result of mechanical courses operating on the substance of the cell-wall in the course of its development from a highly viscous fluid to a more rigid condition.

"*The Effect of Nitrogen-fixing Organisms and Nucleic Acid Derivatives on Plant Growth.*" By W. B. BOTTOMLEY.

The products of the nitrogen-fixing organism, *Azotobacter chroococcum*, are shown to have a marked effect in increasing the rate of growth of plants of *Lemna minor* in water culture, and the derivatives of nucleic acid, which the author has found can be extracted from raw peat, are also able to act as accessory food substances. The addition of these two separate materials to the culture solution increased the number of plants from 1817 in mineral solutions only to 96,921 and 80,179 respectively in the liquids containing these substances.

Not only was the rate of multiplication increased by these organic materials, but the plants supplied with them maintained their normal size and health, 100 plants from the two series containing these substances weighing respectively at the end of the experiment 18·6 and 18·7 mgrms.; while 100 plants from the series growing in pure mineral nutrients weighed only 4·7 mgrms.

When both the nucleic acid derivatives and the *Azotobacter* products were added together to the culture solution, the number of plants obtained was 293,171, an effect practically identical with that of bacterised peat, for the series containing this latter extract showed 292,864 plants in the same time.

The nitrogen-fixing organism, *Bacillus radicicola*, is found to have a similar effect to that of *Azotobacter chroococcum*.

A similar series of experiments was carried out with the ash of the crude nucleic acid derivatives and of the *Azotobacter* growth, and neither of these materials had the slightest effect on the rate of multiplication or the health of the *Lemna* plants.

It is therefore the *organic* material which is so essential for the complete metabolism of these plants, and they cannot maintain their normal growth and vigour for any length of time without the presence of small quantities of organic substances.

"*The Vegetative Morphology of* Pistia *and the Lemnaceæ.*" By AGNES ARBER.

Anatomical examination of the "limb" of the leaf of *Pistia Stratiotes*, L., the river lettuce, shows that, in addition to normally orientated vascular bundles, there is a series of inverted bundles towards the upper surface. This fact is regarded as indicating that the leaf is of the nature of a petiolar phyllode. This interpretation is extended to the distal part of the frond of the Lemnaceæ (Duckweeds).

The general view, put forward by Engler forty years ago, as to the morphological relation of the Araceæ—through *Pistia*—and the Lemnaceæ, is accepted in the present paper, and it is shown that more detailed investigation by modern methods makes it possible to carry the comparison considerably further.

Serial sections through a developing shoot of *Pistia* reveal the presence of a "pocket" in connection with each leaf, occurring below the level of the free part of the limb. This pocket is formed on one side by the leaf-sheath and on the other side by the axis, and encloses a bud occupying a lateral position in relation to the limb of the leaf. It is shown that these pockets are exactly equivalent to the pockets at the base of the frond in the Lemnaceæ, which in the case of *Spirodela* are easily seen to be formed on the lower side by the wings of the leaf-sheath terminating in two minute ligular flaps, and on the upper side by the axis.

"*Effects of Exercise and Humid Heat upon Pulse Rate, Blood Pressure, Body Temperature, and Blood Concentration.*" By W. J. YOUNG, A. BREINL, J. J. HARRIS, and W. A. OSBORNE.

1. Vigorous exercise of short duration caused :—

(*a*) An increase in the pulse rate and blood pressure, both of which rapidly fall to normal after discontinuation of the exercise.

(*b*) An increase in the carbon dioxide percentage of the alveolar air.

2. The alveolar air at rest in inhabitants of tropical Queensland showed a lower carbon dioxide content than the European average.

3. Prolonged exercise led to a rapid increase in the pulse rate and temperature at first, which increase became more gradual afterwards, and in the case of blood pressure even fell on occasions below normal, on account of the profuse sweating. Prolonged exercise had but little effect on the alveolar air. The body temperature during the exercise continued to rise slowly, but, considering the light nature of the exercise, the rise in temperature was considerable.

4. A considerable loss of water from the body was observed as the result of prolonged exercise. Blood estimations showed that this water was mainly derived from other sources in the organism than the blood plasma; a small concentration of the blood plasma, however, had taken place.

5. The hot-room experiments gave results similar to those caused by prolonged exercise, with this difference, that the pulse rate and body temperature rose more gradually at first, but a quicker rise took place afterwards.

6. The results point to the fact that both exercise and humid heat play a part in producing a rise in blood pressure, pulse rate, and rectal temperature. The degree of rise, however, is controlled by atmospheric conditions, which influence the rate of cooling of the body.

GEOLOGICAL SOCIETY.

November 5, 1919.

Mr. G. W. LAMPLUGH, F.R.S., President, in the Chair.

A LECTURE was delivered by HUGH HAMSHAW THOMAS, M.A., F.G.S., "*On some Features in the Topography and Geological History of Palestine,*" illustrated by aeroplane photographs taken during the War.

The lecturer observed that a perfectly new method of illustrating and investigating some branches of physical geology is afforded by Aeroplane Photography. It seems first y to illustrate in a very striking and convincing form many geological phenomena, such as the structure of a volcano or the land-forms resulting from erosion, and may be of value in the teaching of the science. In the second place it may, in certain circumstances, become a valuable means of research, especially in connection with river-development or denudation in a region which is somewhat inaccessible, or where the surface of the ground very

complicated and the main features are obscured by a mass of less important detail. The lecture deals principally with the illustration of the physical features of Palestine, and owes its origin to the systematic photo survey made over Central Palestine during the War. The photographs were originally taken for the purpose of constructing detailed maps, and the examples shown have been selected from a large mass of similar material which still exists in the form of negatives, and these may eventually become available in this country for further study and research. The demarcation of the coastal plain from the foot-hills of the upland country is often well shown by oblique air-photographs, and the weathering-out of the flat alluvial ground by the winter rains to give characteristic wadis is clearly seen. In the central hill-country the terraced hills show the relation of the scenery to the underlying rock, but their general sculpture is regarded as belonging to a former period of great precipitation. In arid country, where the underlying rock is laid bare, the aeroplane camera often shows the general geological structure of the district.

The lacustrine deposits of the Jordan Valley and their weathering was shown, and also the form of the drainage-channels running down into the main valley. The depression of the Dead Sea with reference to the surrounding country has resulted in canon formation in many places. Some evidences of faulting at different periods can be distinguished.

The Jordan at present forms an interesting study in river-development, and many of its main features were demonstrated. The relation of the Jordan to the Orontes has been considered, and an aeroplane photographic survey of the country between the two rivers indicates that the Jordan probably originated in Northern Syria in earlier times. The Syrian portion of the stream has been captured by the younger Orontes, and this has had a very important effect on the whole topography of the Jordan Valley.

A further study of the aeroplane photographs already taken, and of the maps made from them, may throw much new light on the questions of climatic changes and of topographical changes due to faulting in Palestine.

NOTICES OF BOOKS.

A Text Book of Rand Metallurgical Practice. By Ralph Stokes, J. E. Thomas, G. O. Smart, W. R. Dowling, H. A. White, E. H. Johnson, W. A. Caldecott, A. McA. Johnstone, and C. O. Schmitt. Volume II. Second Edition. Pp. xxii+462. Charles Griffin and Co., Exeter Street, Strand, London. 1919. Price 25s. net.

This valuable work has been compiled by several authors, each dealing with a branch of the subject of which he has expert practical knowledge; and, although it is "a practical book for practical men," the fundamental principles upon which modern practice has been built up and from which improvements may be anticipated have been carefully kept in view. This volume is divided into two parts, the first dealing with the design and construction of reducing plants, and the second dealing with the transport of materials. The first part commences with a chapter on the general considerations which have to be taken into account before erecting new plant, and includes plans showing the advances made in recent years in the general lay-out of reducing plants. The chapters following give details of the plant used in each operation through which the ore passes after reaching the surface. Working drawings and photographs are given in each case of several types of machinery and buildings used in different mines. The section is terminated by two chapters on Estimating and Cost of Reducing Plants; the former giving typical schedules for estimating the cost of each portion of the plant, and the latter giving the capital outlay and working costs of plants in use and tables showing the profit obtainable with different types of plant and methods of extraction.

The second section of the book describes in detail the different methods employed for transporting material, in various stages of reduction, about the works, and gives tables showing the actual cost of the methods used in different mines.

A good bibliography and index complete the volume, which is exceedingly well written and contains over four hundred illustrations.

We are of opinion that it will prove to be of great value to all interested in this branch of metallurgy.

The Papermakers' Directory of All Nations, 1919. London: Dean and Son, Ltd., 160a, Fleet Street, E.C. Pp. lvi+879. Price 17s. 6d.

The 28th Edition of the "Papermakers' Directory of All Nations" contains information invaluable to those in the paper industry.

It has been reviewed; the re-settlement of the Map of Europe affecting the Mill entries, which have been re-arranged as far as possible to agree with the geographical position they are likely to hold in the future; for instance, the Mills in Alsace-Lorraine will now be found under France, and separate headings are given for Hungary, Czecho-Slovakia, Yugo-Slavia, Poland, Livonia, and the Ukraine.

The book is arranged in three main sections—(1) List of Paper Mills and allied trades in the United Kingdom, (2) Mills in Foreign Countries and the Colonies, and (3) List of Mill Productions of all Countries.

A Buyers' Guide is also included.

CORRESPONDENCE.

MUTAROTATION.

To the Editor of the Chemical News.

Sir,—Some time ago I urged that the term Mutarotation should not be applied to the change in optical rotation which occurs when ethyl tartrate reacts with phosphorus trichloride (*Trans. Faraday Soc.*, 1914, x., 94). Dr. Lowry, the author of the expression, replied that he saw no objection to Prof. Grossmann's use of the word in this connection (*Ibid.*, p. 95). On the other hand, Prof. Irvine has expressed the opinion that "it is necessary to retain the expression mutarotation for reversible reactions, from which the unaltered sugar may be recovered, and to exclude all cases such as those quoted by Grossmann and Block, who describe, as mutarotations, optical changes such as those shown by sucrose in formic acid solution. Any permanent reaction carried out on an active substance in solution might on this basis be described as mutarotation" (*Trans. Chem. Soc.*, 1915, cvii., 1240). It was anticipated that the application of the name mutarotation to the rotatory changes accompanying all chemical reactions of active compounds in solution would lead to confusion in the minds of students of stereochemistry.

Prof. Stewart in the section entitled Mutarotation in the recent edition of "Stereochemistry" makes the surprising statement that "in some cases, of which ethyl tartrate is the best representative, mutarotation is observed," and devotes a paragraph to a discussion of the so-called mutarotation of this compound. Dr. Lowry having admitted his failure to detect mutarotation in ethyl tartrate (*Trans. Chem. Soc.*, 1915, cvii., 1179), it is evident Prof. Stewart is referring to the instantaneous optical changes which are brought about by an alteration of temperature or the addition of a solvent. If other writers

follow the example of Profs. Stewart and Grossmann, the phenomenon known as mutarotation will no longer be confined to changes of rotation with time or to transformations of a reversible character. It is to be hoped that chemists will be unwilling to allow an expression which has been so serviceable in the past to become merely a synonym for any "change of rotation.—I am, &c.,

G. W. Clough.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

To the Editor of the Chemical News.

Sir,—In my capacity as General Treasurer of the British Association for the Advancement of Science, I made, before the Thursday evening discourse, at the recent Bournemouth Meeting, the following remarks:—

Ladies and Gentlemen,—You are aware that after paying printing and office expenses, the funds of the British Association are devoted to Scientific Research. For more than eighty years we have spent more than £1000 a year on Research, long before ordinary people had heard of Research.

Every year we form many research committees; each of them is formed of the foremost men of science of Great Britain, who receive none of the money themselves, and their accounts for mere out-of-pocket expenses are carefully audited. These researches in the past have created some entirely new sciences, have led directly and indirectly to the creation of many new industries, and they have largely produced the world's present natural knowledge. And now to my point. Yesterday a very prominent member of the Association asked me about our finances. I had to admit that even before the War we were meeting with difficulties due to the increased cost of printing and other things; that since the War we have been behindhand to the extent of more than £1000 every year, and that we have never yet asked for the help of moneyed men. The only gift we have ever received from a moneyed man was a voluntary gift from Sir James Caird, who handed me £11,000 at the Dundee Meeting. My questioner said we ought to ask for help, and that he was willing to start a fund with a sum of £1000. At this moment he does not wish to have his name mentioned.

I need not dwell on the importance of our Research work, as I feel sure that every person here who has himself done original work shares my opinion that when we limit our expenditure on Research, and especially on pure scientific research, we shall begin to be a bankrupt Association—bankrupt, that is, morally from the point of view of science, if not actually in the financial sense.

The moneyed men of Great Britain are most willing to help any good object when they get proof that it really is a good object. We cannot complain of want of their help, for they did not know the facts. At the same time, the treasurer of an Association with such a record as ours does not feel happy at the prospect of begging for help.

In the two days of the Meeting following that on which I made this statement the funds were raised to a total of £1475. I intend to pubish in due course a list of names of donors and donations.

To illustrate by many instances (as I might) our claims as to the importance of our researches would unduly prolong this letter, and any selection of a few examples would be unrepresentative. I will cite a single illustration. The National Physical Laboratory, the scene of researches of which the importance to the nation during the War and earlier cannot be overestimated, had its origin (if its antecedents be traced backwards) in the Kew Observatory which was maintained by the British Association from 1842 to 1872, in which period the Association spent some £12,000 on its upkeep.—I am, &c.,

John Perry.

Burlington House, London, W. 1.

NOTES.

At the meeting of the Manchester Literary and Philosophical Society held on Tuesday, November 18, Sir Henry A. Miers, M.A., D.Sc., F.R.S., Vice-Chancellor of the Victoria University of Manchester, was elected President of the Society in succession to Prof. G. Elliot Smith, M.D., F.R.S.

Dr. R. H. Pickard, D.Sc., Ph.D., F.R.S., has been appointed Principal of the Battersea Polytechnic. Dr. Pickard has been Principal of the Municipal Technical School, Blackburn, since 1908, and has been for some years Consulting Chemist to the Corporation of Blackburn and the Blackburn Cotton Employers Association. He has done much for the advancement of Chemical knowledge by the publication of the results of his Researches in the Transactions of various learned Societies. During the war his services as a Research Chemist were given voluntarily to the Explosives Supply and Chemical Warfare Committee of the Ministry of Munitions.

MEETINGS FOR THE WEEK.

Monday, December 1.

Royal Society of Arts, 8. (Cantor Lecture). "Synthetic Drugs," by J. T. Hewitt, F.R.S.

Wednesday, December 3.

Royal Society of Arts, 4.30. "The Oil Seed Crushing Industry," by J. W. Pearson.

Society of Public Analysts, 8. "New Distillation Method for Detecting Adulteration in Butter and for Estimating Fats of the Coconut Group," by George van B. Gilmour. "An Investigation into the Composition of the Unsaturated Hydrocarbons present in Coal Gas," by F. S. Sinnatt and L. Slater. "A New Process for the Determination of Arsenic, with Notes on the Chemistry of the Marsh-Berzelius Process," by B. S. Evans.

Thursday, December 4.

Royal Society, 4.30. "The Adsorption of Gases at Low and Moderate Concentrations—I. Deduction of the Theoretical Adsorption Isotere and Isotherm; II. Experimental Verification of the Form of the Theoretical Isoteres and Isotherms; III. Experimental Verification of the Constant in the Theoretical Adsorption Isotere," by A. M. Williams. "On the Secondary Spectrum of Hydrogen," and "On the Spectra of Isotopes," by T. R. Merton. "A Study of Catalytic Action at Solid Surfaces," by E. F. Armstrong and T. P. Hilditch. "An Experimental Determination of the Critical Electron Velocities for the Production of Radiation and Ionisation on Collision with Argon Atoms," by F. Horton and Ann C. Davies.

Friday, December 5.

Technical Inspection Association, 7.30. "Inspection and Testing of Materials," by R. D. Summerfield and H. J. Davey.

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THE CHEMICAL NEWS

VOL. CXIX., No. 3112.

THE HYDRIDES OF THE METALLIC ELEMENTS.

By J. FREDERICK CORRIGAN

SINCE the days of Lavoisier it has been a well established fact that most metals, when heated in oxygen, readily combine with the gas, with the formation of extremely well defined compounds—oxides. The readiness of oxygen to combine with metals is shown by the fact that some metals, such as potassium and sodium, rapidly form oxides even when exposed to the gas at ordinary temperature.

It was also found later that a number of metals formed similar compounds with nitrogen when they were heated in an atmosphere of nitrogen or ammonia gas. To these compounds the name "nitride" was given. Nitrides are formed much less readily than are oxides, and combination of the metal with the nitrogen usually only occurs at a bright red heat. The metals titanium and radium are amongst the exception to this rule, nitrides being formed when the metals are exposed to air.

In recent years a stimulus has been given to the study of the nitrides by the application of these compounds in industrial operations, ammonia being now commercially prepared when certain nitrides are treated with super-heated steam (Surpeck process).

$$2AlN+3H_2O = Al_2O_3+2NH_3.$$

On the discovery of arsenic hydride by Gehlen in 1815, and antimony hydride by Thompson in 1837, attention was drawn to the fact that, under certain conditions, hydrogen could also be caused to combine with a number of metals, and to these compounds the name "hydride" was applied. As the nitrides are formed much less readily than are the oxides, so much the less readily are formed the hydrides than are the nitrides. Interest in these compounds appears to have waned, and with the exception of Graham's classical researches on the occlusion of hydrogen by certain metals very little work seems to have been done on the subject until the close of the nineteenth century. This lack of interest in the subject may perhaps be accounted for by the fact that, with few exceptions, no well defined hydrides were obtained, and that when hydrogen was observed to be absorbed by metals the phenomenon was always explained by Graham's occlusion hypothesis.

Hydrogen, when passed over many heated metals, gives rise to two or more phenomena. In some cases the gas enters into combination with the metal, with the production of a definite compound—a hydride—of more or less different physical and chemical properties than the metal. In other cases, notably with palladium and platinum, the phenomenon of "occlusion" is brought about, and no chemical combination appears to take place, the hydrogen merely forming a solution with the metal, and being given up when the metal is heated under reduced pressure. In a third case, the metal also appears to occlude hydrogen, and at the same time a certain amount of a definite hydride is produced and can be detected.

Adsorption or Occlusion of Hydrogen.

Some metals, particularly palladium and platinum, absorb large quantities of hydrogen. Thomas Graham (1867-9) found that palladium will absorb 935 times its volume of hydrogen at red heat and 276 times its volume at ordinary temperatures. The amount of hydrogen actually absorbed by the metal depends upon its physical condition, metals in the finely-divided state absorbing considerably greater quantities than metals in the coherent form.

According to Neumann and Strientz one volume of various metals in the finely-divided state is capable of absorbing the following amounts of hydrogen :—

	Vols.		Vols.
Palladium . ..	502·35	Nickel	17·57
Platinum.. ..	49·3	Copper	4·5
Gold..	46·3	Aluminium ..	2·72
Iron..	19·17	Lead	0·15

Williams (CHEMICAL NEWS, 1884, lii., 205; 1885, liii., 146) states that commercial zinc dust contains thirty-nine times its volume of occluded hydrogen, which is completely given up when the zinc dust is heated under reduced pressure. He concludes that the absorbed hydrogen must have somehow been derived from the moisture contained by the zinc dust.

Hydrogen has also been found occluded in specimens of meteoric iron.

The absorption of hydrogen by palladium is readily seen by making a strip of palladium foil the negative electrode of a cell containing acidulated water, the positive pole being of platinum. On electrolysing the water, oxygen will be evolved from the positive pole, but for some time no gas will be disengaged at the negative pole, the hydrogen being completely absorbed by the metal.

Graham observed that palladium undergoes an increase in volume during the absorption of hydrogen, the increase in length of a palladium wire being 1·6 per cent. This change in volume of the metal during absorption of hydrogen may be demonstrated by employing two strips of palladium-foil, protected on one side by a coating of varnish, as electrodes in an electrolytic cell. On passing the current the negative electrode begins to bend over towards the varnished side.

"Hydrogenised palladium," as palladium containing absorbed hydrogen is sometimes called, is able to perform many chemical reactions which ordinary hydrogen cannot do. It can reduce ferric chloride to the ferrous state :—

$$FeCl_3+H_{palladium} = FeCl_2+HCl.$$

It is also able to reduce chlorates to chlorides, nitrates to nitrites, mercuric chloride to mercurous chloride, ferricyanides to ferrocyanides, and indigo blue to indigo white (Gladstone and Tribe, CHEMICAL NEWS, 1878, xxxvii., 68),

Hydrogen occluded in platinum, copper, or iron produces similar changes, although to a less degree.

A number of these reactions have been made use of in quantitative analysis (Chapman, *Analyst*, 1904, xxiv., 346).

Johnson (*Journ. Chem. Soc.*, 1876, i., 178) found that when copper wire is oxidised in the blowpipe, and subsequently reduced in hydrogen at red heat, hydrogen is occluded to the extent of 0·0063—0·0077 grm. for 100 grms. copper, the hydrogen being weighed as the moisture produced by igniting the charged metal in dry air and absorbing the water in sulphuric acid.

He also believes that the hydrogen occluded by the copper is probably often the cause of an error on the side of excess in the determination of hydrogen in the analysis of nitrogenous organic substances.

Theories of Occlusion.

Graham gave to the phenomenon of the absorption of hydrogen by metals the name of "occlusion," from the Latin *Occludo*—I shut up. According to Graham, the hydrogen condensed to a solid on the surface of the metal and then formed an alloy with the metal. To this hypothetical solid he gave the name "Hydrogenium," to indicate its supposed metallic nature. As solid hydrogen, however,

has rather the properties of a non-metal than of a metal, Graham's theory is no longer tenable, as the term "alloy" is only strictly applicable to the union together of metals.

According to Troost and Hautefeuille, it is probable that a definite compound of hydrogen and palladium exists, of the composition Pd_2H. This assumption has been contradicted by some, although the available evidence leans towards the existence of the compound.

The phenomenon of occlusion is now generally referred to as "adsorption," meaning that the gas adheres to the surface of the metal in some way. The relation between the absorbed hydrogen and the metal is as yet unknown.

Definite Compounds of Hydrogen with the Metals—Hydrides.

Hydrogen enters into combination with a number of metals with the formation of definite compounds. The hydrides so produced are usually solid amorphous compounds, practically the only exceptions being the hydrides of antimony and tellurium, which are gaseous at the ordinary temperatures.

General Methods of Formation and Preparation.

Although the metals generally show idiosyncrasies in the methods of formation of their hydrides, the general methods of formation and preparation of these compounds may be stated as follows:—

1. By heating the finely-divided metal to red heat in an atmosphere of hydrogen, either at the ordinary pressure or under increased pressure. (This method is applicable chiefly to the alkali metals, the metals of the alkaline earths, and in a less degree to the metals of the rare earths).

$$Ca+2H = CaH_2.$$

2. By heating a compound of an alkali or alkaline earth metal to a high temperature, and then acting upon it with a saturated hydrocarbon, such as methane (F. S. Machalshe).

3. When heated in an atmosphere of hydrogen the alkaline earth nitrides yield ammonia, and the hydride of the metal.

$$Ca_3N_2+6H_2 = 3CaH_2+2NH_3.$$

4. Oxides of the rare earth metals, when mixed with magnesium powder and heated in an atmosphere of hydrogen, yield hydrides (C. Matignon, *Chem. Zeit.*, 1900 xxiv., [97], 1062).

The metal is first reduced to the finely-divided state by the magnesium powder, and is then acted upon by the hydrogen with the formation of a hydride.

$$ThO_2+2Mg = Th+2MgO,$$
$$Th+2H = ThH_2.$$

5. By acting upon zinc ethyl, $(C_2H_5)_2.Zn$, with anhydrous ferrous iodide in the presence of dry ether, Carius and Wanklyn obtained, together with zinc iodide, a mixture of gases consisting of ethylene, ethane, butane, and free hydrogen. The residue, after washing with dry ether, yields a metallic looking powder, which does not alter in air, and which evolves hydrogen on heating and is decomposed by water, leaving a residue of metallic iron and ferrous oxide. This substance is considered to be a compound of hydrogen with iron and to have the formula Fe_2H_2.

6. When a solution of copper sulphate is acted upon by hypophosphorous acid or its sodium salt, the former is reduced even beyond the metal, and a precipitate of a dark brown hydride results.

$$3NaH_2PO_2+4CuSO_4+6H_2O = $$
$$= 3H_3PO_4+H_2SO_4+3HNaSO_4+2Cu_2H_2.$$

This reaction is employed as a test for hypophosphorous acid and its salts.

7. Antimony and tellurium hydrides are formed when compounds containing antimony or tellurium are introduced into a mixture generating hydrogen, such as zinc and sulphuric acid.

8. When hydrogen, obtained from the action of steam on magnesium, is burnt, a green flame is obtained. The same coloration of the flame is also obtained, but to a less degree, when the hydrogen, obtained by the action of hydrochloric acid upon magnesium, is burnt.

French (CHEMICAL NEWS, 1899, lxxx., 261) investigated the above conditions, and obtained indications of metallic mirrors from the evolved hydrogen. The hydrogen thus obtained is considered to contain a volatile magnesium hydride.

9. Sabatier and Maihle (*Ann.*, 1910, [viii.], xx., 289) have studied the catalytic oxidation of the primary alcohols by the following metallic oxides:—ThO_2, Al_2O_3, Cr_2O_3, TiO_2, BeO, ZrO_2, UO_2, Mo_2O_5, Fe_2O_3, V_2O_3. ZnO, MnO, CdO, Mn_2O_3, and MgO.

They have come to the conclusion that hydrides of the above metals are produced, but are immediately decomposed, yielding the metal which then reacts with a further quantity of the alcohol, thereby producing a continuous reaction:—

Alcohol + Metal → Metallic Hydride + Aldehyde
↑ ↓
└——— Metal + Hydrogen

(To be continued).

THE

ACTION OF BROMINE ON CALCIUM CARBIDE.

By EDWARD BARNES, B.Sc.(Lond.).

MOISSAN (*Comptes Rendus*, cxviii., 501; also "The Electric Furnace") states that when bromine vapour is passed over heated calcium carbide the products are calcium bromide and carbon, while in the cold bromine has no action on calcium carbide. Venable and Clark (*Journ. Am. Chem. Soc.*, xvii., 306—310) report the same results. No other reference to this subject has been found.

The calcium carbide used in this work was selected from a large quantity of the commercial product. The pieces selected were highly crystalline, as it was expected that these would be the purest. The outside layer was removed from the pieces, and they were rapidly reduced to a fairly fine powder just before use. One grm. of this carbide gave 210 cc. of acetylene, thus indicating that it contained 63 per cent of CaC_2. Ordinary bromine was used after purification. It was purified by being left in contact with concentrated H_2SO_4 for a day, after which it was separated and distilled from the water-bath, the whole apparatus being of glass.

In some preliminary experiments quantities of roughly powdered carbide were placed in stoppered glass cylinders and covered with bromine and set aside. After about six weeks it was noticed that the bromine had been absorbed entirely. The product was a reddish brown mass throughout which colourless crystals were interspersed. On heating, this substance deflagrated vigorously and evolved bromine. On analysis, this product was found to consist of calcium bromide, hexabromethane (C_2Br_6), and unchanged calcium carbide. The C_2Br_6 was extracted from the product by means of CS_2 in a Soxhlet apparatus. It was obtained as a white crystalline powder. It was identified by determining its bromine content and by its behaviour on heating. It was found to contain 95·25 per cent of bromine (lime method). The theoretical value for C_2Br_6 is 95·23 per cent. On heating, it began to evolve bromine at 205° C., and by 215° it had liquefied. The $CaBr_2$ was identified by the usual tests after the unchanged CaC_2 had been decomposed by water and the resulting calcium hydrate had been filtered off.

In a subsequent experiment 4·5 grms. of finely powdered CaC_2 and 45 grms. of dry bromine were placed in a 50 cc. bottle, the neck of which was drawn out and sealed. In this case more bromine was used than was sufficient to complete the reaction. The bottle was set aside and occasionally examined. At first the calcium carbide formed a thin layer on the surface of the bromine. The layer gradually increased in thickness till eventually the contents of the bottle consisted of a thick paste. It took about five months for this change to take place. The neck of the bottle was opened, and the excess of bromine was removed by placing the bottle in a desiccator containing potash, and evacuating. The solid residue (32·4 grms.) was extracted with CS_2, whereby 22 grms. of C_2Br_6 was separated. The part insoluble in CS_2 was treated with water and the gas evolved was collected. Less than 50 cc. was obtained, representing only about 0·2 grm. of unchanged carbide. The solution was filtered from impurities and evaporated to dryness, whereby 8·8 grms. of $CaBr_2$ was obtained. The quantities of $CaBr_2$ and C_2Br_6 obtained are practically the quantities theoretically derivable from the 4·5 grms. of 63 per cent carbide used.

These experiments indicate satisfactorily that liquid bromine acts slowly on calcium carbide at ordinary temperatures, producing carbon hexabromide and calcium bromide, $CaC_2+4Br_2=CaBr_2+C_2Br_6$.

Several sealed tubes containing CaC_2 and Br were heated to 100° C. in a boiling water-bath till no further change was apparent (six hours a day for several weeks). On analysis the product was found to contain carbon and calcium bromide, but no carbon hexabromide.

A number of experiments on the action of dry chlorine gas on calcium carbide at ordinary temperatures were carried out. Several grms. of finely powdered CaC_2 were exposed to the action of 15 litres of dry chlorine for about two months. No carbon hexachloride or other organic substance was found in the product, which appeared to be unchanged CaC_2.

Iodine acts on calcium carbide at 170° C., producing tetriodethylene and diiodacetylene (*Beilstein Erg.*, i., p. 56). Fluorine acts on calcium carbide at ordinary temperatures, giving calcium fluoride and carbon tetrafluoride (Moissan, "The Electric Furnace").

THE HARDENING OF STEEL.*

By Prof. H. C. H. CARPENTER, F.R.S.

(Concluded from p. 251).

I pass now to consider three of the most modern theories of hardening. Two of these were enunciated simultaneously and independently in May, 1914, the third in November of the same year.

The first of these is due to Dr. McCance. As already mentioned, he showed that when the carbon reaches about 0·7 per cent a maximum hardness is obtained in the quenched state, and this value is not exceeded in any pure carbon steel. He reasons that if the hardness were the direct consequence of carbon in solution it would be proportional to the amount of carbon dissolved; that it is not so shows that the action of carbon is indirect, and that the hardening element is the iron itself. In the annealed condition the ball hardness of this steel is 174, while in the hardened condition it is 713.

Holding as he does the view that β iron is not a definite allotrope of the metal, but merely α iron which is non-magnetic from purely thermal causes, McCance considers that at Ar_2 γ iron passes directly to α. He explains the liberation of heat at A_2 as being due to the rapid change in specific heat which necessarily accompanies the ferro-magnetic transition. He points out that since α iron loses its magnetic properties above a certain temperature, it might be suggested that γ iron, which at higher temperatures is non-magnetic, might itself become magnetic at lower temperatures. Hadfield has shown, however, that non-magnetic manganese steel (γ iron) is not transformed even at the temperature of liquid air; and McCance reasons that as no treatment can make austenitic steel magnetic which does not increase the specific volume at the same time, this points conclusively to its transformation to α iron, since the thermal magnetic transition makes no appreciable alteration in the specific volume. His theory of hardening is based on the following considerations and reasoning:—Since steels, which at the temperature of quenching are non-magnetic are magnetic in the hardened state, this change must have taken place during the time taken by the quenching; therefore some of the original γ at any rate must have changed to the magnetic α condition. Measurements of the electrical resistance, however, show that the carbon still remains in solution; therefore under the conditions of quenching the transformation of the iron from the γ to the α state can take place independently of the change in the state of the carbon from one of solution to that of precipitation. Thus these two transformations, which on slow heating and cooling take place simultaneously, can behave as independent reactions, although in a limited sense. "For, though martensite may be considered as an enforced solution of carbon in α iron, it must not be forgotten that there is still some γ iron present with the carbon, which is absolutely necessary to maintain its solubility, and any change in the state of the carbon causes this transformation of γ iron to α. It might be on this account be suggested that the iron is chemically combined with the carbon, but an examination of the curve connecting the loss of magnetic saturation intensity with the carbon content shows that the γ iron increases much more rapidly than the amount of carbon, which points to purely physical influences" (*Transactions of the Faraday Society*, 1914, p. 56). Mc Cance then considers the cooling of a hypo-eutectoid steel, that is, one containing rather less than 0·9 per cent carbon. As he points out, its complete transformation into α iron and cementite involves two distinct transformations—(*a*) a change in the state of the iron from γ to α; (*b*) a change in the state of the carbon. The first of these can take place independently of the second, but when the second takes place it necessarily involves the first. There are therefore three possible conditions:—

1. Both transformations are completed, producing pearlitic steel which is soft.

2. Both transformations are suppressed. This has never been achieved with any pure iron carbon alloy, and the addition of a certain amount of manganese is necessary, as Maurer has shown. In this case pure austenite results, and this, while harder than the steel in the pearlitic condition, is nevertheless softer than a hardened steel.

3. When (*a*) takes place, but (*b*) is suppressed, then the resulting structure is martensitic, and, according to McCance's theory, the α iron formed under this condition is interstrained and very hard. Case 3 then is the important one from the hardening standpoint, and to be possible it is necessary that a difference should exist in the respective velocities of transformation of (*a*) and (*b*), so that with an appropriate rate of cooling the slower transformation can be suppressed, while the faster still takes place. On McCance's view then, it is interstrained α iron which is the cause of the hardening of steel. He does not, however, accept Beilby's theory of a hard vitreous amorphous phase. His view of interstrain is as follows:—"Metals in their normal unstrained condition are crystalline, that is, they are composed of an orderly arrangement of their constituent atoms arranged in a space-lattice which conforms with whatever symmetry the crystals possess. Successful attempts have been made by the aid of X-rays to determine the actual position occupied by the atoms, and copper, for instance, has been shown to have its atoms built up in a "faced-centred" cube, that is, a

* A Lecture delivered at the Royal Institution, March 7, 1919.

cube having an atom at each corner, and one at the centre of each face. The effect of deformation on such systems must be to alter the position of each atom relatively to its neighbour, and permanent deformation must cause so much alteration that the atom along the planes of slip can no longer return to their positions of equilibrium. This corresponds to the condition of interstrain and results in a hardening of the material" (*Transactions of the Faraday Society*, 1814, p. 53). McCance admits that the destruction of the crystalline arrangement does go so far as to render the material in these planes of greatest movement actually amorphous, but appears to deny that the amorphous phase is hard.

The important connection between rate of cooling and hardening is well illustrated by the behaviour of alloy steels. If, for instance, manganese is added to the steel it lowers the temperature of the transformations and greatly decreases their velocities, so that with sufficient manganese even at ordinary rates of cooling the structure is martensitic, and the steel very hard and brittle. The addition of even more manganese ultimately prevents any transformation taking place, even when the steel has cooled to the ordinary temperature, and a pure austenitic steel is the result. If the martensitic manganese steel be water-quenched, not only is it not hardened but is actually softened, this being due to the complete suppression of both transformations and resulting in the production of an austenitic steel. Similar results may also be obtained with nickel.

The following experiments quoted by McCance are also important as bearing out his contention that the main cause of the hardening of steel lies in a change in the iron itself. A steel containing 3·6 per cent nickel and 0·19 per cent carbon had a normal hardness of 183, which on quenching in water from 1000° C. had risen to 144, whereas a steel containing the same amount of carbon but no nickel increased after the same treatment from 143 to 218. In other words, whereas the carbon steel increased only 65 points, the nickel steel was augmented by 259. As nickel does not form a carbide in this range of composition, the state of the carbon is similar in both alloys, consequently the increased hardness must be due to the influence of the nickel on the iron, and McCance explains this by the view that the iron is enabled to retain a greater degree of interstrain by lowering the temperature at which the transformation of γ to α iron takes place. He rightly lays stress on the importance of internal friction in retarding transformations and preserving metastable states.

McCance's theory of hardening has been built up by acute reasoning on a solid foundation of well-established facts. As yet, however, it cannot be regarded as constituting a *complete* theory, because it is intentionally non-committal with regard to the expression "interstrain." As he points out, the theory of interstrain action is in itself an inquiry, and that inquiry has yet to be undertaken.

The second of the most modern theories of hardening was put forward by Prof. Edwards and myself (*Journal of the Iron and Steel Institute*, No. 1, 1914, pp. 138—177). We started from the position that steels are not the only alloys which can be hardened by quenching in water from moderately high temperature. Many alloys, in fact, are known which possess this property. The difference is one of degree and not of kind. Steels, in fact, are simply the higher members of a group of different alloys which possess the same characteristics in varying degrees. Further, all the alloys which behave in this way have similar constitutions at high temperatures, and undergo precisely similar changes as they cool to atmospheric temperature. They undergo decomposition at certain critical temperatures which are marked by evolutions of heat. It is generally admitted that the hardening produced by quenching any of these alloys is in some way related to the effect of quick cooling upon these critical heat changes. Within certain limits the effect of varying the rates of cooling upon the Ar_1 change in steels and other similar changes is well known. As the rate of cooling is increased, the temperature at which the changes occur is progressively lowered, and simultaneously the thermal magnitude is decreased. It is therefore in agreement with established facts that, as the rate of cooling is increased, there is an increased tendency to prevent the critical change taking place, and to keep the heat of the change suppressed. The careful experiments of Prof. Benedicks show that when the highest quenching velocities are attained there are no indications of any heat at all being evolved. Logically, therefore, these facts appear to point to the view that the hardening is connected with the suppression of the heat of the inversion. If this be the case, energy has to be brought to bear upon the specimen during the quenching process in order to overcome the tendency for the inversion to take place. This energy is considered to be brought to bear in two ways:—

1. By the sudden contraction of the outer shell or envelope of the specimen.

2. By an internal molecular contraction of the mass which is connected with the solution or osmotic pressure of the dissolved carbon in the case of steel.

This explanation, so far as it goes, is a perfectly general one, applicable to all alloys which may be hardened by quenching.

The next step in the argument is as follows:—In the case of all alloys hardened in this way when the heat change is suppressed, severe internal stresses are set up which exceed the elastic limit, and consequently cause an internal straining of the material. That, in the case of steels, the metal is internally strained appears to us well established. According to the view put forward by us in 1914, martensite is simply twinned austenite produced by this internal movement, and further along the twinning planes amorphous material is produced by the distortion of the crystalline units, which material we regard as corresponding to Beilby's hard vitreous-amorphous phase produced by mechanical work. In order to establish this theory therefore evidence should be produced that these actions take place. For such evidence in full the original paper must be consulted, and only the briefest *résumé* can be given here. The view that internal straining occurs during the quenching of steel has only been challenged by one authority, Dr. Rosenhain, who says:—"This view meets with the insuperable difficulty that although quenching does set up severe stresses in steels, it does not cause any serious flow or movement; the strain hardening of metals only become marked when severe plastic flow has occurred." This objection however breaks down on examination. It is true that in cold working a metal a large degree of strain is needed to produce great hardness, but in this case the direction of strain is constant throughout the mass, so that the strains are additive, and these result in a great change of outer dimensions. But the strains in the slipping planes set up by hardening from quenching are quite different. They are not in constant but in opposite directions along different internal planes, and they therefore offset each other and do not deform the mass as a whole. That severe straining does not occur therefore may be accepted as established. The microscopic evidence for this straining was regarded by us in our original paper as being due to a great development of twins in the steel. It was pointed out, however, in the discussion that, although twinning might have occurred, this would not necessarily cause any increase in hardness, since the two halves of every twin should dovetail into each other, and therefore amorphous material need not necessarily be produced in the twinning planes. This may be so, but for the purpose of this theory it does not matter whether the movement is regarded as taking place along twinning or along slip planes; in the latter case it is generally agreed that amorphous material must result by the distortion of the crystalline units. According to this view, then, martensite is austenite which has been distorted by the formation of amorphous films along the

slip planes of γ iron. It will be observed that I have already begun to use Sir George Beilby's theory of the hard amorphous state in order to explain the hardening of steel by quenching, by suggesting that amorphous material is formed along the slip planes of γ iron. What is now required is to show, if possible, that these layers persist on quick cooling. Beilby has shown that when strain-hardened metals are heated, the amorphous layers recrystallise, and the actual temperature at which this occurs varies with the particular metal and with the degree of strain hardening. Accordingly, if in quenching the rate of cooling is sufficiently quick, the temperature of the mass will be lowered below that at which recrystallisation occurs. In the case of pure iron it has been shown by Chappell and Goerens that the minimum temperature for the strain hardening of iron is about 500° C. It is quite certain that the minimum temperature for a steel containing 0·9 per cent carbon will be higher than this. How much is not known, but let the figure 500° C. stand for this particular steel. In hardening the steel is quenched from a temperature which should not be higher than 800° C. The important interval therefore in the quenching operation is between 800° C. and 500° C. In one of Benedicks' experiments, to which reference has been already made, the time taken to pass through this interval was exactly one second; in the case of a tool of abont one inch diameter it will take longer for the centre to pass through this interval, but the probability is that it will not take more than two to three seconds for the skin of the tool to pass through this interval. In such a case, therefore, our view is that the vitreous amorphous layers formed will certainly not have time to recrystallise, but will be preserved, and hardening will result. It will follow, then, that the final cause of hardening by quenching is exactly the same as that of hardening by cold working. In the case of tool steels and other alloys of a similar nature, the actual stresses which are set up in quenching, which give rise to the twinning or slipping, are brought into action only in the very brief period during which the mass is cooling; therefore, while the metal is undergoing intercrystalline slip and the amphorous layers are being formed, the chances for these to recrystallise become less and less as the cooling proceeds. Indeed it may be that a large proportion of the slipping which occurs takes place at moderately low temperatures below that at which the amorphous layers are able to recrystallise. Put briefly, then, our theory of the hardening of steel is, that it is due to the formation of hard vitreous-amorphous films of a solution of carbide in γ iron formed along the slipping planes of the austenite.

So far as I am aware, there is only one property of quenched steels which is not accounted for by this theory, namely, that all quenched steels are magnetic. It has not been shown that amorphous γ iron is not magnetic, though it is not at all probable, since the property of magnetism is almost certainly associated with a definite orientation of the molecules in iron and steel. Admitting, as may be done on present evidence, that ferro-magnetism is a property of α iron, our theory can be brought into harmony with the fact that all quenched steels are magnetic, by adopting McCance's view that some γ iron passes to α in the quenching of all steels.

The third modern theory of hardening to which I wish to allude was put forward some six months after the two theories which have been briefly outlined. It is due to Mr. J. C. Humfrey (*Transactions of the Faraday Society*, 1914, pp. 35-43). This theory rests upon the assumption that a hard amorphous phase is responsible for the hardness of quenched steel, and in this respect resembles the theory put forward by Prof. Edwards and myself. The formation of this phase, however, is attributed to entirely different considerations, which will now be briefly set forth. Mr. Humfrey considers in the first place what happens when one allotropic form of an element passes into another. He starts from the theory of crystal structure already alluded to in McCance's theory, namely, that the centres of gravity of the molecules are arranged together according to one of a series of geometrical devices, called space-lattices. In each molecule of such a crystal the atoms are similarly situated.

When an allotropic change occurs in such a crystalline body, there is an internal rearrangement of the atoms in each molecule, and if the new form which the molecules take involves a corresponding change in the external forces which they exert upon one another, the space-lattice may become unstable and a different one formed. Before, however, the reorganisation can be completed, it is assumed that there must be temporarily a state of disorder, and it is during this period that Humfrey considers that the structure must be considered as amorphous. This intermediate state is regarded as corresponding to the liquid "which would be formed by the fusion of the solid phase stable at the lower temperatures, if the conditions could be so adjusted that the subsequent recrystallisation were avoided." The temperature-tenacity curves obtained by Rosenhain and Humfrey are regarded as indicating that the melting-points of α and β iron would be considerably lower than that of γ iron, if they could be preserved unchanged up to their melting-points.

In the next place consideration is given to the fact that physical changes of state do not take place instantaneously throughout the whole mass of any given substance, but that they start from certain nuclei and proceed outwards. From this Humfrey conceives that the intermediate amorphous phase existing during an allotropic phase begins to recrystallise almost as soon as it is formed, "and is present at any particular instant during the change, merely as thin films or layers between the co-existing crystalline phases, the films moving forward as the change progresses. The course of the breakdown of the one crystalline phase to the amorphous would tend to follow those planes in which the freedom of movement was greatest, namely, the crystal-gliding planes and possibly the intercrystalline boundaries."

With regard to the formation of a new crystalline phase Humfrey points out that the temperature at which it occurs must not be too low for the forces of crystallisation to overcome the viscosity of the amorphous phase. If the viscosity is sufficient to prevent recrystallisation, the amorphous phase formed will be practically stable. Even in cases, however, where an allotropic change normally takes place at a temperature well above that at which the viscosity is sufficient to prevent recrystallisation, abnormal conditions such as rapid cooling may delay the change to well below this temperature. He then applies these general considerations to the case of steel. γ iron normally inverts to β iron at about 900° C. The recrystallisation of work-hardened α iron is very slow below 500° C. This gives an interval of 400°. In the case of the 0·9 carbon steel, however, this range is halved, since γ iron does not invert till about 700° C. on cooling. From this it is argued that with increasing carbon contents there is more likelihood of some of the amorphous phase formed by the breakdown of the γ constituent being retained than in pure iron itself. Another factor also enters in which helps to promote the retention of the amorphous phase. Not only the iron, but also the iron carbide has to be considered. When the austenite breaks down, the carbide molecules are regarded as remaining "closely intermingled with those of the α iron." Before the amorphous material can recrystallise two different kinds of molecules have to segregate, those of iron and its carbide: this segregation must be a slow progress in an undercooled viscous mass, and rapid cooling is regarded as allowing the minimum temperature of crystallisation to be passed before it has had time to take place.

Benedicks has shown that pressure aids the retention of the austenitic condition in steels. The change from the crystalline to the amorphous state in metals is in practically all cases accompanied by an increase in volume; γ iron is denser than α iron, and therefore even denser than amorphous α iron. Accordingly Humfrey argues that

after the formation of a certain amount of amorphous material, the pressure set up will be sufficient to retain some of the austenite in the unchanged condition. According to him, then, the particular structure known as martensite is due to two constituents—(1) γ iron (austenite); (2) "an amorphous solution of α iron and carbide"; the form in which the two constituents occur being due to the tendency of the austenite crystals to break up along their gliding planes. It will be seen therefore that the conclusion reached by Humfrey is almost identical with that arrived at by Prof. Edwards and myself, but that the actual mechanism of the change is different.

As to whether on passing from one allotropic form to another it is necessary to assume the existence of an intermediate amorphous state as postulated by Humfrey, it is not necessary for my present purpose to discuss. It may be pointed out, however, that the passage from the crystalline to the amorphous condition involves the absorption of energy, and he has not explained how that energy can be supplied from the interior of a cooling mass of material, and to render the theory complete in this respect an explanation must be forthcoming. On the other hand, when, as Prof. Edwards and I have supposed, both slipping and perhaps twinning of the austenite crystals occur as a result of the quenching stresses, energy is absorbed and may be stored up in the amorphous layers.

Within the limits of this lecture it has not been possible to consider anything like the whole of the evidence which may be brought to bear on the problem of the cause of the hardening of steel by quenching. In particular, that which is furnished by the behaviour of alloy steels, specially those containing nickel or manganese, or both, has enabled the conditions intermediate been austenite on the one hand, and pearlite on the other, to be studied in a more systematic and comprehensive way than is possible with pure carbon steels. Moreover, the discovery and widespread use of the so-called high-speed cutting tools, all of them alloy steels, has widened the scope of the problem to an extent which could not have been realised as recently as twenty years ago. It will be observed that the three modern theories, of which some account has been given, present considerable resemblance to one another, in spite of certain differences which are obvious on the surface. The theories of Humfrey and Edwards and myself attribute hardening to the existence of a hard amorphous constituent in the steel. McCance does not go so far as this, but regards interstrain as the cause of hardness, a condition which I think it is fair to describe as occupying an intermediate position between crystalline and amorphous materials. Perhaps at no very distant date McCance will develop a theory of interstrain action.

The acute differences which divided sharply the allotropists and the carbonists find no counterpart in the schools of thought of to-day. Indeed it is interesting to reflect for one moment on the position of the allotropic theory of Osmond, in the light of the most modern views on the subject. According to these, M. Osmond was correct in attributing hardness to something—stated in its most general terms—intermediate between crystalline γ and crystalline α iron. The view that this intermediate something is a crystalline β iron such as he supposed has not been completely abandoned, but is not held by many workers to-day. This conception has given place to the interstrained iron of McCance and the amorphous iron and iron-carbide complex of Humfrey, Edwards, and myself.

The important influence exerted by carbon, insisted upon by the carbonists, is fully recognised in the modern theories described. Speaking with the ampler knowledge of to-day one may summarise the position by saying that the older theories, tested and to some extent corrected by this, have contributed to a broader view of the matter, in which their apparent differences have been put into their proper proportion, and the elements of truth they contained incorporated into other theories which, for the time being, are more in accord with such knowledge. That these in their turn are likely to be modified and amplified by the advance of knowledge I should be the first to admit.

USE OF ELECTRICITY IN AGRICULTURE.*

With Special Reference to its Development in Germany.

By JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

(Continued from p. 253).

Electric Motors.—The applications of electricity for power purposes in agriculture fall generally under two headings—(*a*) Where the electric motors are permanently installed in particular positions; (*b*) Where the electric motors are portable and only introduced when and where they are required, as for the operation of threshing machines, ploughs, &c.

It is recommended that motors should be permanently installed where the work is of such a nature as to require regular repetition at short intervals of time, and generally where the machine to be driven is permanently fixed, as, for example, in many pumping plants where the motor is switched on and off automatically. In such cases the motor may either drive a group of machines by chain gearing or by belts, on the system known as "group electric driving," or each machine may be provided with a special motor. The latter system is called "individual electric driving," and has much to recommend it.

Portable motors owe their origin and construction principally to the peculiar working conditions in agriculture, and are suitable for those cases which very often occur in agricultural work, where the various machines over the estate do not all require to be used at one time, but one after the other for a short period. In such cases the provision of a special motor for each machine would not be economical.

The portable electric motor also has the special advantage for agricultural purposes that it can be easily brought to any place where the work has to be done, and can be used without any danger of fire, which exists with gas, petrol, or steam traction engines, even when the greatest precautions are taken. Electric motors can be used, for instance, in barns, forage lofts, corn lofts, &c.

Portable motors may be divided into the following classes depending on the method adopted for transporting them from one place to another:—

	Size of motor.
(*a*) Motor cradles	0·3 h.p. up to 2 h.p.
(*b*) Motor sledges	2·5 to 11 h.p.
(*c*) Motor trucks	2 to 14 h.p.
(*d*) Motor wagons	(1) 10 to 20 h.p. (2) 20 to 40 h.p. (3) 40 to 55 h.p.

All these various types are connected to the low-tension conductors by a flexible insulated cable attached to them. A plug is fastened to the free end of this cable, which can be inserted into the permanent socket on the supply circuit, which may, for instance, be attached to the wall of the barn or to one of the poles of the overhead line, &c. The plugs and sockets, and the outer cover of the cable have to be specially designed to meet the severe requirements of rough agricultural work. The speed of the motors is usually 1000 to 1500 r.p.m., and they are supplied for the standard supply voltages.

(*a*) Dealing first with motor cradles. In these a standard three-phase motor is supported on a wrought-

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iron frame fitted with carrying tubes, which can be removed (*Fig.* 5). *The motor is completely enclosed to* protect it from injury and to prevent the entrance of dust, moisture, and air containing ammonia, frequently found in agricultural work, for instance, in stables. Owing to the dust in straw-cutting or in fodder lofts, it is very desirable that the motors should be provided with rain-proof and dust-proof covers. This has the advantage that the motors can be fixed in the open air and need not be brought back immediately to some covered place, which would interrupt work, if a light shower of rain should fall.

The cradles are supplied either without gear reduct.on or with a suitable toothed wheel gearing to give a gear ratio of 1·6, which is the gear ratio generally used. This enables the motor, which must be made for high speed (if it is to be of small weight and cost) to be used for driving slow running machinery. A sheet metal cover prevents the toothed wheels from being touched.

In order to make the motor cradles suitable for as many different purposes as possible they are provided with a belt pulley having two rope grooves. In the case of cradles without gear reduction the pulley is fastened to the motor shaft, and where gear reduction is used to the back gear shaft. If desired, the motor shaft, in the case of cradles with gear reduction, can carry another driving pulley provided with a rope groove, while pulleys of different diameters may also be fitted to the driven machines themselves. In this way the different speeds required to drive the individual machines in agricultural work can be obtained.

Owing to the limited space available for a motor cradle, the starting switch and safety fuses are fixed to the motor in a rain-proof case. The safety fuses which serve to protect the motor from excessive overloading are so connected with this switch that they are only connected in the motor circuit when the switch is in the full working position, and are short circuited so that no current passes through them when the motor is being started up. This arrangement prevents the fuses blowing every time the motor is started, due to the proportionately high starting current, and thus expense is not incurred through exchanging fuse cartridges, while, further, the motor is actually protected on the basis of its allowable overload capacity.

With the motor is usually included a 10-metre length of special connecting cable, one end of which is permanently fastened to the motor terminals. When the motor cradle is moved this cable is carried on a special cable saddle fixed to the motor, which is made to carry altogether about 30 metres of cable.

The weight of the motor and cradle of the 2 h.p. size with toothed wheel gear and pulley, and including connecting cable, is about 100 kgrms. The complete cradle can thus be carried even up and down steps by two persons without difficulty.

(*b*) Where motors are required which are too heavy for cradles, but for the movement of which wheels or wagons are not absolutely necessary, wooden sledges are used on which the motor and necessary switchgear are placed (see Fig. 6). These sledges consist of two wooden baulks with iron fittings as runners. These baulks are connected by wooden cross-pieces, and are provided with four wrought-iron hooks to which chains or ropes can be fashioned for moving the sledge. When the motor is running these chains are fastened to suitable iron pegs in the ground. The motor, which is of the slip-ring type, and its switchgear are protected against moisture, &c., by a light, removable, sheet metal, ventilated cover which can easily be removed at any time to examine the apparatus.

As speeds of 1500 and 1000 r.p.m. are usually suitable for work for which motors above 2 h.p. are used, it is not usual to fit back gearing to these motors, which are, therefore, only fitted with a standard belt pulley of a size depending upon the output, and provided with two rope grooves.

To start the motor the trap door at the side is opened, *and with motors up to about* 5 h.p. *a star delta switch* is used, if the supply authorities do not object to the rush of current at start. If, however, a high starting torque is required, a drum type starter and resistance in the rotor circuit are used.

For outputs above 5 h.p. simple drum type starters suitable for the rough handling they are likely to receive in agricultural work are fitted.

Safety fuses are provided to protect the motor from excessive overloads, and are placed near the starter.

The special brackets for carrying the cable are fastened to one of the short sides of the removable cover.

(*c*) Motors too large to be conveniently handled if mounted on a cradle or on a sledge are carried on a motor truck (Fig. 7), which consists of a small two-wheeled truck which can be moved either by men or by animals, and on which is fixed an ordinary three-phase motor having a slip-ring rotor with the necessary switch-gear. To protect the motor and its accessories, these may be of the rain-proof type, or they can be of the ordinary plain type and protected against being touched, and against rain, snow, dust, &c., by means of a sheet metal cover. To the back of this cover may be fixed the cable bracket to carry the cable when the truck is moved. A trap door in the front of the cover, fitted with a bolt, gives access to the hand-wheel of the drum starter, and under this cover the main switch and fuses are also fixed.

(*d*) The motor wagon (Fig. 8) consists of a wooden wagon body with strong under-frame and four wooden wheels with iron tyres. The diameter and width of the wheels is so large that the wagon can be easily moved even on bad roads. The interior of the wagon is usually divided by partitions into four separate compartments. In the first of these is placed the motor with its starting gear, in the second the cable drum, in the third the belt pulleys, and in the fourth space is left for the necessary tools, &c.

The wagon body is supported by the two back wheels and by the pivot of the front wheels. It thus rests on three points, and can be used on uneven ground without fear of injury to the framework through unskilled handling. To fix the wagon at the working point, blocks are placed between the wheels, and, in addition, the wagon can be supplied, if required, with a powerful hand-brake.

The electric motor generally fitted is of the ordinary standary type, with a wound slip-ring rotor. It is started by a drum-type controller drum rotated by a hand-wheel which can, if necessary, be changed from the right-hand do the left-hand side or *vice versa*, to save trouble in fixing the position of the wagon.

In addition to the starting regulator, a main switch is provided by which the motor can be entirely switched off from the overhead line. This main switch is attached to the starting regulator so that the working of the motor is completely controlled by the movement of the hand-wheel of the starting regulator. To protect the motor against excessive overloads suitable fuses are provided. The cable is wound on a cable drum, shown in Fig. 8, or supported on cable brackets in the interior of the wagon body. In the former case the connection between the cable and the motor is made by slip-rings fixed on the cable drum. In both cases plug connections are unnecessary, and thus wear and tear on the cable is saved, as well as time, since in using the motor it is only necessary to uncoil the length of cable corresponding to the distance between the wagon and the point of supply.

To the posts of the wagon body a small saddle bracket can be bolted for holding the coiled cable, and also a small iron bracket arm for supporting an electric light fitting, so that threshing, for instance, can be continued without much trouble when it is necessary to work during the night. For this purpose the pole carrying the electric light fitting projects high above the wagon, and is easily maintained in a vertical position.

To be continued).

BRITISH EMPIRE EXHIBITION, 1921.

PRODUCTS AND INDUSTRIES OF THE EMPIRE.

ARRANGEMENTS for this Exhibition are going ahead rapidly, and very important developments are in progress throughout the Empire. The volume of correspondence is enormous, showing the general interest taken in this great undertaking.

The Board of Trade are taking an important part by nominating their Director of the Exhibitions and Fairs Division to officially represent the Government on the Executive of the British Empire Exhibition, thus ensuring the close co-operation of the Government and having all their Exhibition interests under one Director.

The London Chamber of Commerce have honoured the Exhibition by resolution of the Council, giving general support to the enterprise, and appointing their President, Mr. Stanley Machin, and their ex-President, Lord Desborough, to represent the Chamber on the Board of this Exhibition. The commercial influence of the London Chamber of Commerce throughout the world is well known, and will no doubt largely contribute to the success of the Exhibition.

Perhaps the most important development in the way of influence is that His Majesty the King and Emperor has graciously given his direct patronage to the undertaking; this at once gives to the Exhibition a position of social and commercial importance, which will be appreciated throughout the Empire. The name of His Majesty the King commands the loyal respect and veneration of his people throughout the world.

A number of the ruling Princes of India have graciously consented to join the Council. Very important negotiations are in progress with the Government of India of a far reaching character, which will be the subject of further reports.

The office of the Exhibition is 25, Ironmonger Lane, London, E.C.

BOARD OF TRADE ANNOUNCEMENT.

THE Board of Trade have made an Order reducing by 10s. per ton the pit-head price of all coal despatched from collieries in Great Britain on or after Monday, December 1, for household and domestic purposes in the United Kingdom.

The Order provides that the reduction of 10s. per ton shall also apply to coal supplied for the production of gas and electricity for household and domestic purposes.

The Order entails a reduction of 10s. per ton (or 6d. per cwt.) as from Monday in the maximum retail prices of house coal, and instructions to this effect have been issued to Local Fuel Overseers, who have at the same time been requested to review the present retail prices of gas-coke in view of the reductioa in the price of coal.

Factors, merchants, and dealers ordering coal for re-sale for domestic or household purposes are required to give the seller a certificate to the effect that the coal will be re-sold or used exclusively for such purposes. Coal shall be deemed to be bought or sold for domestic or household purposes only when it is bought or sold for the purpose of supplying consumers under the provisions of the Household Fuel and Lighting Order, 1919.

Directions have also been issued by the Controller of Coal Mines under which all coal supplied by collieries for bunkering ships engaged in the coasting trade of the United Kingdom (including fishing vessels, tugs, &c.) on or after Monday, December 1 (including coal supplied under existing contracts), shall be charged at fixed prices in Schedule appended to the Directions. These are the present Schedule A prices, less 6s. per ton. These revised bunker prices correspond as closely as practicable with the present home limitation prices for industrial coal.

Where bunker coal is sold to a broker, merchant, or exporter, the broker's, merchant's, or exporter's commission on re-sale must be charged by way of addition to the colliery price.

PROCEEDINGS OF SOCIETIES.

PHYSICAL SOCIETY.

Ordinary Meeting, November 14, 1919.

Prof. C. H. LEES, F.R.S., President, in the Chair.

A PAPER, entitled "*On the Self-inductance of Single-layer Flat Coils*," was read by Mr. S. BUTTERWORTH.

Two formulæ are established for the computation of the self-inductance of single layer flat coils, one for the case where the inner and outer radii are not very different and the other for the case of small inner radius. The two formulæ are shown to be consistent and capable of including all possible cases. From the formula a table is calculated which enables the inductance to be expressed in the form $L = Qn^2r^3$, in which n is the number of turns per cm., r the outer radius, and Q is a tabulated function of the ratio of the inner and outer radii. Some applications of the table are given.

DISCUSSION.

Dr. ECCLES recalled the very useful paper published by the author some years ago, giving formulæ for thick coils. He found these extremely useful, and felt sure that the results of the present paper would prove equally valuable. He felt that people hardly realised their indebtedness to those who undertook these very laborious calculations for the help of the users of coils.

Dr. E. RAYNER pointed out how useful such formulæ were in the construction of inductances. Almost anyone could make up a resistance to have any desired value; but it was another matter with regard to inductances. With formulæ such as these, however, it was possible with the simplest appliances to construct an inductance to within 1 per cent of the required value.

Prof. G. W. O. HOWE communicated the following:— In the *Archiv. f. Elektroteknik*, 1915, iii., 187, is a paper by J. Spielrein, entitled "The Self-induction of Air-core Spirally-wound Coils" (see *Science Abstracts*, Elec. Eng., 1915, No. 660). Spielrein's final formula is $L = T^2 r_2 f(r_1/r_2)$, where T is the total number of turns, whereas Mr. Butterworth's formula is $L = n_1^2 r Q$, where n is the turns per cm. Since $T = n(r_2 - r_1)$ Spielrein's formula can be written $L = n^2(r_2 - r_1)^2 r_2 f(r_1/r_2)$. Hence—

$$Q = (r_2 - r_1/r_2)^2 f(r_1/r_2) = (1 - r_1/r_2)^2 f(r_1/r_2).$$

Now Spielrein gives a table of $f(r_1/r_2)$ to seven places for all values of r_1/r_2 from 0 to 1 by steps of 0·01. Comparing Spielrein's $f(e_1/r_2)$ with Mr. Bntterworth's Q we have:—

r_1/r_0.	$(f r_1/r_2)$.	$(1-r_1/r)^2 f r_2(2/r_2)$.	Q.
0·0	6·969573	6·969573	6·970
0·5	18·97400	4·74350	4·743
0·9	45 74241	0·4574241	0·4574
1·0	∞	0 × ∞	0

It seems obvious that Mr. Butterworth was unaware of this paper.

The AUTHOR, in reply, said he had not known that Spielrein had tackled the problem. He was afraid it rendered his paper somewhat unnecessary.

Dr. ECCLES pointed out that it was of great importance that two independent investigators obtained results in such striking agreement.

A paper entitled "*An Experimental Method of Determining the Primary Current at Break in a Magneto*" was read by Dr. N. W. McLACHLAN.

A method of obtaining experimentally the current at break in a magneto is described. A condenser is connected across the secondary winding to reduce the voltage below that required to cause sparking at the safety gap. The peak voltage due solely to interruption of the current at any speed is found. The interrupted direct current necessary to give the same peak voltage is also found by using a calibrating circuit. The magnitude of this current is equal to that broken in the magneto. The influence of the secondary condenser on the primary current at high speeds is discussed.

DISCUSSION.

Dr. NORMAN CAMPBELL (communicated the following) —It is quite possible to make satisfactory measurements on the primary current of a magneto by inserting in the circuit a small non-inductive resistance and taking the potential difference across it by means of a rotating "contactor." The total resistance inserted need only be 0·03 ohm; 0·01 for the leads and 0·02 for the measuring resistance. By the use of a suitable potentiometer method a change of 0·02 amp. can then be detected, which is ample for practical purposes. It was found that on increasing the total resistance inserted to 0·11 ohm, the current did not change by as much as 3 per cent; accordingly the disturbance caused by the resistance of 0·03 ohm must be quite inappreciable.

With this arrangement it is possible to test the accuracy of Dr. McLachlan's method by examining whether the secondary peak potential is proportional to the primary current. It was found that it was very accurately proportional when the current was changed by varying the strength of the magnets. By changing that strength within wide limits it seems possible to change all currents and potentials in the circuits without changing appreciably their ratio or wave form.

On the other hand, considerable discrepancies, amounting sometimes to 10 per cent, were found when the secondary peak potential produced by breaking a primary current generated by rotation of the armature was compared with that produced by breaking the same current supplied by a battery. My experience indicates that errors of this order might occur in using Dr. McLachlan's method (allowance, of course, was made for the E.M.F. generated directly in the secondary by rotation of the armature).

For the rest, my experiments agreed in general with those of Dr. McLachlan. Since I have not kept the records I cannot discuss them in detail; but I remember being surprised how different was the open-circuit voltage wave which I found from that shown in Fig. 2.

Dr. ECCLES said that Dr. McLachlan had used an indirect method and then made a series of check experiments to show that the various errors introduced are negligible. Dr. Campbell had mentioned a direct method. He thought that direct methods were preferable where possible; and suggested that the Dufour cathode ray oscillograph would have been the ideal instrument for the investigation of the magneto.

Dr. RAYNER said there was one point about which he felt doubtful. This was on page 2 about ten lines down. The calibrating flux was not employed in the same way as the working flux, one being reversed and the other not. He thought some method might be devised to avoid this discrepancy. He was afraid the power required to work the Dufour oscillograph might be greater than was readily obtained from a magneto.

Dr. ECCLES—An amplifier could be used.

Prof. LEES pointed out that the important thing in these researches was that we were obtaining knowledge about the magneto, which has hitherto been treated almost wholly on empirical lines.

The AUTHOR, in reply, said he had attempted to get a Dufour oscillograph, but had not succeeded. He had tried the method outlined by Dr. Campbell, but without the use of a rotating contactor. The results were unsatisfactory owing to the effect of transients before and after break. (The author's complete reply to the points raised in the discussion will be published in the *Proceedings*).

A new form of Wehnelt Interrupter was exhibited by Mr. NEWMAN.

The Wehnelt Interrupter is not used generally owing to the rapid disintegration of the platinum wire, and also because the current required for the working of the cell is large. If, however, a modified form is adopted these disadvantages disappear. A plate of aluminium, area 50 sq. cm., takes the place of the lead plate, the other electrode being platinum wire sealed in a glass tube. These electrodes are immersed in a saturated solution of ammonium phosphate made alkaline with ammonia. This Interrupter works equally well with direct or alternating currents. In the former case the wire must be made the positive electrode, while with alternating currents the passage of the current is such that the wire is positive to the aluminium. The cell works with a minimum potential difference of 18 volts, but the frequency of the interruptions increases with the applied potential difference.

Capt. C. E. S. PHILLIPS said it was important that the experiments should be repeated on the scale required for ordinary X-ray work. He would be glad to afford the author any facilities he required for this purpose. Had he tried the use of potassium carbonate instead of ammonium phosphate? In the X-ray service in the Army a reliable portable Interrupter was badly required. The objection to the ordinary Wehnelt was that a voltage of 80 to 100 was required.

Mr. W. R. COOPER asked if rectification was essential to the working of the instrument. Would plates of other metals than aluminium work?

Mr. NEWMAN said he had not tried other salts. Any metal would serve, but aluminium was best and required the least voltage.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

Tuesday, November 18, 1919.

"*On the Conservation of Oil.*" By Rear-Admiral PHILIP DUMAS, C.B.

The author commenced by reference to his duties as Principal Secretary of the Royal Commission on Fuel Oil and Engines, which brought him into contact with experts, both practical and theoretical, thus giving him an insight into the use of oil as a fuel in the Navy: he pointed out that the supply of oil fuel for consumption is only about one-thirtieth that of coal, while the needs of oil fuel are growing every day; for this reason it should be treated as a luxury. Instead of this, "Haphazard education and waste of brains, wasteful search, wasteful boring, wasteful production, wasteful storage, wasteful use of main and by-products, wasteful transport, wasteful retail sale, waste in the lack of concentrated chemical research into its constituents, and, lastly, waste in its most economic use" are now being practised.

Dealing with haphazard education, reference was made to the endowment of a Chair of Chemistry for Oil Research at Cambridge, but it was suggested that there should be a Chair at every University. A University for Mining and Chemical Research together with scholarships would be better—the cost would be infinitesimal in comparison with the benefits that would accrue.

With regard to boring, licences should be made and only given to well-founded corporations with ample funds, and before these licences were granted the available storage capacity of tanks should be ascertained.

Wasteful storage is next dealt with: the author states that the tanks in use are generally too small; the storage tanks in great liners should be made with rounded corners,

for storage tanks containing pockets are a positive nuisance.

The waste in use could be partly overcome by penalising a user in relation to the efficiency of his engine.

The author contends that to burn oil for the raising of steam is a waste, while the advantages gained in the use of oil far outweigh the disadvantages. Referring to the use of oil in the Navy, he enumerates sixteen advantages for its use, setting by their side eight disadvantages, including the waste of oil for steam raising; the efficiency of oil to coal is at least 3 to 2, and for the use in internal combustion engines oil is to coal as 4 to 1. The use of oil in the Navy to such a wasteful extent is due to the lack of knowledge of the House of Commons in permitting such laxity; in his opinion the use of oil should only be given to submarines, destroyers, and small craft, the bigger battleships being run on coal with no loss of efficiency. Prior to the war, Germany only used oil in the Navy in times of war, and in the Dutch navy ships were only permitted to use it in the East Indies.

The author then touches on the growth in the use of oil, taking as examples the turn-out of 4000 motor cars per day by the Ford Company, the fact that we can put 15,000 motor lorries on the road, and to its use by aeroplanes. To cope with the use of oil as a fuel he advises a most minute and systematic search everywhere.

Admiral Dumas concludes with a few remarks on the advantages of an internal combustion engine, and predicts that in the near future a suitable internal combustion engine for merchant shipping will be invented, thus saving, roughly, a hundred millions sterling per year and something like half of the oil produced in the world.

SOCIETY OF GLASS TECHNOLOGY.

The November meeting was held on Wednesday, Nov. 19, in the Applied Science Department of the University of Sheffield. In the absence of the President, Dr. W. M. Travers, F.R.S., took the Chair.

The first paper was entitled "*The Reversible Expansion of Refractory Materials*," by H. J. Hodsman, M.Sc., and Prof. J. W. Cobb, O.B.E., and was read by the last named.

Silica refractories on firing have a permanent expansion, whilst fireclay refractories have a permanent contraction. On subsequent heat treatment both types of refractories undergo expansion which is reversible on cooling. The paper dealt with this reversible expansion. The authors briefly expounded methods of measuring expansion at high temperatures, and described in full the methods actually employed in the particular work under discussion. The range of temperature through which reversible expansion had been investigated was 15° C. to 1000° C., and some very remarkable results had been obtained. It was shown that alumina and kaolin expanded regularly within the above temperature range. Silica, whilst having approximately the same mean expansion between 15° C. and 1000° C., behaved very differently at intermediate temperatures. Thus between 15° C. and 500° C. it expanded regularly at a rate slightly greater than that for kaolin. Between 500° C. and 600° C. its mean coefficient of expansion was greatly enhanced, whilst between 600° and 1000° its expansion was practically nil. The anomalous behaviour between 500° C. and 600° C. was probably due to a change from α-quartz to β-quartz. There was nothing in the results to indicate the formation of tridymite between 600° C. and 1000° C.

Curves were shown indicating the behaviour of various materials between 15° C. and 1000° C. A mixture of 80 per cent ganister and clay behaved like silica. Fireclay and potclay behaved similarly to silica, the behaviour being nearer that of silica than that of kaolin, and it was of the nature of the silica curve. Ball clay, alundum, and carborundum behaved similarly to kaolin.

In conclusion, the author discussed the bearing of the results upon the arching and subsequent heating of glass-house pots and other refractories.

The second paper read was entitled "*A Proposed Standard Formula for a Glass for Lamp Workers*." By F. W. Branson, F.I.C., and F. H. Branson, A.I.C.

The authors first reviewed their early work of investigation on pre-war tubing for lamp workers. They then gave an analysis of the tubing they considered most suitable for lamp workers, together with a batch which on melting would give this glass. Tubing had been made from this batch which was satisfactory in every way. It could be re-blown many times without devitrification, and was especially suitable for making plugs, stopcocks, and bulbs. It joined easily with all the best British-made glasses, including the resistant varieties, and was quite suitable for the repair of pre-war imported chemical glassware. The glass was quite free from appreciable colour, and did not darken in the blowpipe flame.

NOTICES OF BOOKS.

The Manufacture of Chemicals by Electrolysis. By Arthur J. Hale, B.Sc., F.I.C. (A Treatise of Electrochemistry). Pp. xi+80. Constable and Co., Ltd., Orange Street, W.C. 1919. Price 6s. net.

As a section of a large Treatise of Electro-chemistry, with which idea the author has apparently written it, this book is undoubtedly useful.

It gives brief descriptions, fully referenced, of many up-to-date patent and ordinary processes for the manufacture of various substances by electro-chemical means, together with an estimate of the efficiency of the process and cost of working.

Among the subjects dealt with are the production of hydrogen in large quantities for balloon work, and of nitric acid and nitrates by the electrolysis *in situ* of peat deposits, the manufacture of per-salts and pigments, the oxidation and reduction of organic compounds, electro-osmotic and electro-colloidal processes, &c.

The author indicates that particular care must be taken in the choice of the electrodes, as in many cases the final product of the reaction depends to a large extent upon their size and the condition of their surface. The use of various salts and metals in a finely divided state, as catalysts, is also important in securing good yields.

Published in its present form, however, as a single volume, the book seems to need backing up by the remainder of the Treatise.

The Profession of Chemistry. By Richard B. Pilcher. Pp. xiv+199. Constable and Co., Ltd., Orange Street, London, W.C. 1919.

The author of this book aims at giving the general public some idea of the importance of the chemical profession, and at indicating to parents and others the course of study which it is advisable for a student to follow should he desire to avail himself of the opportunities offered.

In an early chapter the distinction between chemists and pharmacists is explained in such a way as should clear up the confusion which exists in so many people's minds as to the identity of these two professions.

In the commencement of the book is given a synopsis of the education and training recommended, and this is enlarged upon and explained in the remainder of the volume.

The question of women in professional chemistry is briefly touched upon, and the book is completed by a chapter on the work of chemists in the war—both the men at home engaged in the production of munitions and in research upon various commodities formerly obtained from foreign sources and also those in the Field with the Special Brigade (Gas Service) R.E., and other units.

NOTES.

Royal Institution.—The 94th Course of Juvenile Lectures founded by Faraday at the Royal Institution, will be delivered this Christmas by Prof. W. H. Bragg on "The World of Sound." The lectures will be given on the following days at 3 o'clock. Tuesday, December 30, "What is Sound?"; Thursday, January 1, "Sound and Music"; Saturday, January 3, "Sounds of the Town"; Tuesday, January 6, "Sounds of the Country"; Thursday, January 8, "Sounds of the Sea"; and Saturday, January 10, "Sound in War."

Vegetable Oils.—In the early months of this year, says the *Colonial Journal*, the imports of palm oil showed a substantial increase over those of 1918; but the striking feature was the large increase of cotton-seed, which was nearly ten times the quantity imported in the same months of 1918. In spite of this, however, there was recently a shortage of materials, which can only be explained by a greater consumption. The British manufacture of margarine is now firmly established, which means that at least £10,000,000 a year, which would under the old conditions have gone abroad, is now kept at home. Popular taste greatly favours coco-nut butter, and the price of copra went up decidedly everywhere this spring. It is now about double the figure it stood at ten years ago, and as this commodity is the first thing that the enemy countries will buy on a big scale when they get the chance, it is more likely to rise than fall.

MEETINGS FOR THE WEEK.

Monday, December 8.

Biochemical Society, 5.30.
Ceramic Society, 7.30. "Fine Grinding of Potters' Materials," by L. G. Hill.
Institution of Mechanical Engineers, 8.
Royal Society of Arts, 8. (Cantor Lectures). "Synthetic Drugs," by Dr. J. T. Hewitt.

Tuesday, December 9.

Royal Society of Arts, 4.30. "Problems of the West Indies," by Sir Edward Davson.

Wednesday, December 10.

Royal Society of Arts, 4.30. "Some Possible Sources of Energy," by Sir Oliver Lodge.

Thursday, December 11.

Royal Society, 4.30. "A Further Study of Chromosome Dimensions," by Colonel C. F. U. Meek. "The Respiratory Exchange of Man during and after Muscular Exercise," by J. M. H. Campbell, C. G. Douglas, and F. G. Hobson. "The Energy Output of Dock Labourers during Heavy Work," by Dr. A. D. Waller," F.R.S. "Histological Examination of an Adult Human Albino's Eyeball, with a Note on Mesoblastic Pigmentation in Foetal Eyes," by C. H. Usher. "The Relation of Spermatozoa to Certain Electrolytes," by J. Gray.
Institution of Electrical Engineers, 6.

G R

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NOTE.—For further particulars of other Government Property for Sale, see "SURPLUS," price 3d., at all bookstalls; or by Quarterly Subscription of 2/-, post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1.

Assistant Chemist required for large Engineering Works. Must have experience in the Analysis of Steels and Alloys.—Address, A. C. R., Chemical News Office, 16, Newcastle Street, Farringdon Street, London. E.C. 4.

METALLURGICAL CHEMIST.—Firm of Electrical and Steam Turbine Engineers have a vacancy in their Metallurgical and Inorganic Research Laboratory for College trained man. with some experience, aged 23 to 26. Commencing salary £250 to £300, according to qualifications. Three years' agreement. Annual increases and further prospects upon completion if services are satisfactory. Write full particulars and testimonials to M. C., Chemical News Office, 16, Newcastle Street, Farringdon Street, London, E.C. 4.

METALLOGRAPHIST and MICROSCOPIST (Lady).—Electrical Engineering firm requires, as Senior of Microscopic Research Laboratory, a College trained Lady specialised in Microscopy and Photography applied to general Metallography; also capable of general Micro-chemical Testing of Textile Fibres, Petrology of Inorganic Insulating Materials and Refractories. Must be willing, tactful, and able to handle small staff of assistants (women). Commencing salary £225 to £240. Three years' agreement with annual increases, permanent prospects. Full particulars with testimonials to M. M., Chemical News Office. 16, Newcastle Street, Farringdon Street, London, E.C. 4.

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ROYAL SOCIETY.

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THE CHEMICAL NEWS

VOL. CXIX., No. 3113.

A MODIFICATION OF SKRAUP'S SYNTHESIS FOR PREPARING QUINOLINE BASES: THEIR CONVERSION INTO STANNICHLORIDES

By J. G. F. DRUCE. B.Sc., A.I.C.

THE success which attended the synthesis of quinoline from aniline stannichloride (CHEMICAL NEWS, 1918, cxvii., 346) has prompted the author to make further experiments to ascertain whether the new method could be utilised for the preparation of alkyl quinolines and higher bases.

The procedure adopted was as follows:—The aromatic amine stannichloride was mixed with glycerol, and concentrated sulphuric acid was carefully added, causing an evolution of hydrochloric acid gas. After this had subsided the contents of the flask were maintained at about 120° for some hours, then allowed to cool, diluted, and diazotised with sodium nitrite solution, boiled, cooled, made alkaline, and usually steam distilled to yield the oily base which was immiscible with water.

Skraup and Vortmann prepared phenanthroline (*Monatsh.*, 1882, iii., 571), and pseudo-phenanthroline (*Ibid.*, 1883, iv., 570), from the reduction products of the nitro-anilines with tin and hydrochloric acid, *i.e.*, from the double tin chlorides of the phenylenediamines, which they mixed with more of the nitro-compound and treated with glycerol and sulphuric acid.

Their experiments have been repeated and modified, but the yields of the phenanthrolines were disappointingly low and the products were difficult to obtain pure.

In none of the present preparations was the yield of quinoline base as high as that obtained for the parent substance from aniline stannichloride. Thus the *p*-toluidine salt gave a 70 per cent yield of 6 methylquinoline, the *m*-toluidine salt gave 7-methylquinoline, and *o* toluidine salt gave 8 methylquinoline in yields of 25 and 0 per cent respectively.

Although these yields are not very high it should be remembered that the quantities obtained by the older methods were always very small, and recently, for quinoline itself, Mikeska, Stewart, and Wise (*Journ. Ind. Eng. Chem.*, 1919, xi., 456), by the nitrobenzene method obtained a yield of 65 per cent, calculated on the aniline taken and disregarding the nitrobenzene also used; whereas the quinoline obtained from aniline stannichloride (*loc. cit.*) was 80 per cent of that theoretically possible.

The three methylquinolines have been converted into their stannichlorides by treatment in hydrochloric acid solution with stannic chloride. The salts obtained are briefly described below together with the stanno- and stanni-chlorides of *m*-toluidine.

A rapid method of estimating the chlorine content of these double salts has been devised and which served as a useful check upon the results obtained by the usual analytical procedure. It consisted in the titration of aqueous solutions of known quantities of the double haloids with standard decinormal sodium hydrate solution, using phenolphthalein as the indicator. Solutions of stanno- and stanni-chlorides were always strongly acid towards indicators owing to dissociation or hydrolysis. Addition of alkali rapidly completed the hydrolysis, whereby all the chlorine in the salt was converted into hydrochloric acid which would then be exactly neutralised and estimated by the alkali.

The course of the hydrolysis may be represented :—

$$B_2H_2Sn^{II}Cl_4 + 2H_2O \rightleftharpoons 2B + 4HCl + Sn(OH)_2$$

and—

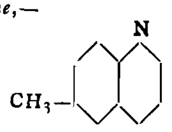
$$B_2H_2Sn^{IV}Cl_6 + 4H_2O \rightleftharpoons 2B + 6HCl + Sn(OH)_4.$$

Further results obtained with double tin chlorides whose preparation has been previously described are also given (CHEMICAL NEWS, 1919, cxviii., 1 and 87).

It will be noticed that quite good results are obtained with aromatic compounds, but the stronger basicity of the amine in the case of the aliphatic salts does not permit of so accurate an estimation of chlorine by this method.

Experimental.

6-Methylquinoline,—



—Eighteen grms. of *p*-toluidine stannichloride were mixed with an equal weight of glycerol by warming and shaking in a round flask of 500 cc. capacity. The mixture was allowed to cool and 30 grms. of concentrated sulphuric acid were gradually added. Hydrochloric acid gas was evolved on shaking, which was carried out in a fume cupboard. When no more fumes were evolved the flask was maintained at about 120° for two and a-half hours. After cooling, the contents of the flask were diluted with 100 cc. of water and shaken. Sodium nitrite solution was carefully added until, on withdrawal, a drop of the solution blackened starch potassium iodide paper. The mixture was boiled after standing for an hour, cooled, made alkaline with a strong sodium hydrate solution, and steam distilled.

6-Methylquinoline separated as an oil below the water in the receiver, and 6·3 grms. of the base were isolated by means of a small separating funnel. The aqueous layer was faintly alkaline to methyl-orange, but ether failed to extract a further weighable quantity of the base. The liquid had the odour of quinoline, but when dried by diluting with ether and standing for two days over anhydrous calcium chloride, filtering, and removing the solvent, it boiled at 255—257°. A portion was dissolved in dilute hydrochloric acid, and gave the yellow picrate on adding a saturated solution of picric acid.

6-Methylquinoline Stannichloride,—

$$(CH_3.C_9H_6N)_2.H_2SnCl_6.$$

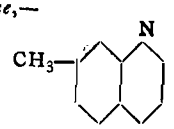
—The base (3 grms.) was dissolved in 50 cc. of dilute hydrochloric acid together with 3·6 grms. of crystalline stannic chloride by stirring and warming. The solution deposited small thin shining white plates when cold. The crystals melted at 248°, and dissolved in cold water to a clear solution which required heating before hydrolysis became pronounced. They dissolved in alcohol, but not in benzene, ether, chloroform, acetic acid, or carbon tetrachloride. On analysis :—

0·5253 grm. gave 0·1335 grm. SnO_2; Sn = 20·03 per cent.

0·5253 grm. gave 0·7245 grm. AlCl; Cl = 34·13 per cent.

$(CH_3.C_9H_6N)_2H_2SnCl_6$ requires Sn = 19·16 and Cl = 34·32 per cent.

7-Methylquinoline,—



—*m*-Toluidine stannichloride (15 grms.) was mixed with 15 grms. of glycerol and 25 grms. of concentrated sulphuric acid were slowly added with shaking in a fume cupboard. After half-an-hour all the acid had been added and no more hydrochloric acid gas developed. The mix

ture was heated at about 120° for three hours, and subsequently treated as in the preparation of 6-methylquinoline. Steam distillation yielded a pale yellow oil (1·1 grms.), which had an odour resembling but distinct from that of quinoline.

7-Methylquinoline Stannichloride,—

$(CH_3.C_9H_6N)_2.H_2SnCl_6$.

—The base (1 grm.) was dissolved in 25 cc. of dilute hydrochloric acid, together with 1·3 grms. of stannic chloride crystals. The solution was boiled, and on cooling deposited very pale yellow transparent short needles, which were filtered off, washed with dilute acid, drained and dried between sheets of bibulous paper. The salt dissolved readily in cold water, but the solution deposited a gelatinous precipitate on standing, and became cloudy when gently warmed. The substance melted at 229°. On analysis :—

0·4203 grm. gave 0·0999 grm. SnO_2; Sn = 18·73 per cent.

0·2465 grm. gave 0·3469 grm. AgCl ; Cl = 34·82 per cent.

Theory requires Sn = 19·16 and Cl = 34·32 per cent.

8-Methylquinoline,—

—Eighteen grms. of *o*-toluidine stannichloride were mixed with an equal quantity of glycerol, and 30 grms. of concentrated sulphuric acid were added in small amounts with shaking. The mixture was treated as in the preparation of the other methylquinolines, and yielded 3 grms. of a pale yellow oil which had the odour of quinoline, and slowly darkened on keeping for some weeks. Its hydrochloric acid solution gave a precipitate of platinichloride when a few drops of platinic chloride solution were added. The salt was orange-yellow when prepared, but gradually turned to a brownish colour.

8-Methylquinoline Stannichloride,—

$(CH_3.C_9H_6N)_2H_2SnCl_6$.

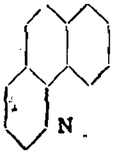
—The base (1·5 grms.) was dissolved in dilute hydrochloric acid (40 cc.) together with 1·8 grms. of stannic chloride. The solution was boiled, and on cooling deposited short white needles in felted masses. These were filtered off, drained, and dried. The salt did not dissolve very well in cold water ; with warm water hydrolysis resulted. It was slightly soluble in alcohol, but did not dissolve in any other common organic solvent. On heating it melted with decomposition at 252°. On analysis :—

0·3050 grm. gave 0·0783 grm. SnO_2; Sn = 20·21 per cent.

0·3050 grm. gave 0·4178 grm. AgCl; Cl = 33·91 per cent.

Theory requires Sn = 19·16 and Cl = 34·32 per cent.

Phenanthroline,—



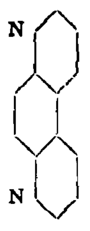
—*m*-Phenylene diamine stannichloride (15 grms.) was mixed with 18 grms. of glycerol, warmed, and allowed to stand overnight. Concentrated sulphuric acid (24 grms.) was slowly added with shaking. A vigorous effervescence took place. When it had subsided the flask containing the mixture was heated for four hours at about 140—150°. After cooling, the mixture was diluted with 120 cc. of water and again cooled, diazotised with sodium nitrite solution, and allowed to remain overnight. It was then boiled for fifteen minutes and then cooled.

At this stage the solution was yellowish brown but transparent. It was made alkaline with 20 per cent sodium hydrate solution and finally extracted seven times with alcohol-ether mixture.

A yellowish resinous residue remained after removal of the solvent. The substance was treated with hot dilute hydrochloric acid, boiled with animal charcoal, and filtered whilst hot. Potassium dichromate solution was added to the filtrate and precipitated crude insoluble phenanthroline dichromate.

This precipitate was filtered, washed with cold water, and boiled with aqueous ammonia which became orange-coloured as it liberated the base. The residue was filtered off, washed with cold water several times, and finally boiled with alcohol. The solution was filtered off and allowed to evaporate slowly. About a grm. of a granular crystalline product was obtained, which melted at 75—77°, and was insoluble in cold water, benzene, ligroin, and cold ether. It was slightly soluble in hot water and alcohol, to which it imparted a pale brownish colour.

ψ-Phenanthroline,—



—This was prepared in a similar way to the above from 14 grms. of *p*-phenylenediamine stannichloride. The crystals obtained (less than 1·5 grms.) were coloured brown and began to melt at 163°. (Skraup and Vortmann, *loc. cit.*, gave the melting-point as 173°). In solubility this compound resembled the above.

Addition of *m*- or *p*-nitroaniline to the reactants in the last two preparations, in accordance with the procedure of Skraup and Vortmann, did not improve the yield, but seemed to increase the quantity of brown resinous products simultaneously formed.

m Toluidine Stannochloride,—

$(CH_3.C_6H_4.NH_2)_2.H_2SnCl_4$.

—The base (5·35 grms.) and stannous chloride crystals (5·65 grms.) were dissolved together in 50 cc. of strong hydrochloric acid diluted with 50 cc. of water. A clear solution was obtained on heating, and a mass of pearly white plates separated on cooling. These were isolated, examined, and analysed. They melted at 76°, and were soluble in cold water and alcohol. On analysis :—

1·4390 grm. gave 0·4524 grm. SnO_2 ; Sn = 24·76 per cent.

0·6008 grm. gave 0·6709 grm. AgCl; Cl = 27·63 per cent.

$(C_7H_7.NH_2)_2.H_2SnCl_4$ requires Sn = 24·90 and Cl = 29·75 per cent.

m-Toluidine Stannichloride, $(CH_3.C_6H_4.NH_2)_2.H_2SnCl_6$. —The stannichloride used in the preparation of 7-methylquinoline was obtained from 10·7 grms. of *m*-toluidine and 17·75 grms. of stannic chloride, which were dissolved together in 100 cc. of concentrated hydrochloric acid diluted with 120 cc. of water by heating. On cooling, a mass of pale pink nacreous plates was deposited. These crystals were filtered off, drained and dried between sheets of bibulous paper. The mother-liquor yielded a second crop of crystals on concentration and subsequent cooling. The crystals were somewhat soluble in cold water, but the substance was hydrolysed when the solution was heated.

On heating, the solid began to darken at about 255°,

and melted sharply at 284° to a deep brown liquid. On analysis:—

0·7135 grm. gave 0·1972 grm. SnO_2; Sn = 21·77 per cent.

0·7135 grm. gave 1·1248 grm. AgCl; Cl = 39·01 per cent.

$(C_7H_7NH_2)_2.H_2SnCl_6$ requires Sn = 21·67 and Cl = 38·84 per cent.

m-Toluidine stannochloride could not be converted into the stannichloride by direct chlorination in dilute hydrochloric acid, but when chlorine water was added with stirring to a solution of the salt in strong hydrochloric acid addition of chlorine took place, and the concentrated solution deposited crystals identical in appearance and melting-point with those obtained above.

TABLE I.

Stannichlorides of—		Wt. of salt taken. Grm.	N/10 NaOH required. Cc.	Per cent chlorine. Found.	Per cent chlorine. Theoretical.
6-Methylquinoline..	1	0·1728	16·65	34·18	34·32
" ..	2	0·1436	13·8	34·12	34 32
7-Methylquinoline..		0·2730	26 9	34·97	34 32
8-Methylquinoline..	1	0·1542	14·75	33 94	34·32
" ..	2	0·1858	17 9	34·16	34·32
m-Toluidine	1	0·2831	31·3	39·18	38·84
" ..	2	0·3782	42·6	39·04	38 84
o-Toluidine (*a*) ..	1	0·4065	41·45	36 17	37 64
" ..	2	0·3447	35·3	36·31	37·64
p-Toluidine		0·3172	33·1	36·96	37 64
Quinoline		0·1969	19·5	35·14	35·95
Pyridine	1	0·2113	25 6	42·94	43 81
" ..	2	0·1854	22·35	42 75	43·81
Methylaniline.. ..	1	0·4155	46·3	39·49	38·84
" ..	2	0·1738	19·1	38 97	38·84
Dimethylaniline ..	1	0·4080	43·5	37·80	37·01
" ..	2	0·2602	27·3	37·25	37·01
Benzylamine		0·3308	34·15	36·62	38·84
m-Phenylenediamine	1	0·2844	39·3	49·01	48 18
" ..	2	0·4508	62·5	49·03	48·18
p-Phenylenediamine		0·1219	16·7	48 65	48·18
Diethylamine.. ..	1	0·2145	25·5	42·14	44·35
" ..	2	0·3362	40·65	42·88	44·35
Trimethylamine ..	1	0·1894	24·25	45·49	47 09
" ..	2	0·2370	30·9	46·21	47·09

(*a*) *o*-Toluidine stannichloride,—

$(C_7H_7.NH_2)_2.H_2SnCl_6.H_2O$.

(CHEMICAL NEWS, 1919, cxviii., 88).

TABLE II.

Stannochlorides of—		Wt. of salt taken. Grm.	N/10 NaOH required. Cc.	Per cent chlorine. Found.	Per cent chlorine. Calculated.
Methylamine		0·1398	17·7	44·81	46·42
Ethylamine	1	0·1641	17·9	38·63	39·29
" ..	2	0·3144	33·05	37·29	39·29
Trimethylamine ..		0·2542	25 65	35·78	37·27
Aniline (*b*)	1	0·3707	32 9	31·49	31·58
" ..	2	0·2296	20·3	31·32	31·58
Methylaniline.. ..	1	0·2034	18·3	31 92	31·93
" ..	2	0·2107	18·75	31·56	31·93
Dimethylaniline ..	1	0·2936	23·45	28·31	28·20
" ..	2	0·2048	16·8	29 07	28·20
m-Phenylenediamine		0·2589	28·1	38·47	37·97
o-Toluidine		0·3517	29 35	29 60	29·75
m-Toluidine		0·3097	24·5	28·07	29 75
p-Toluidine		0·2409	19·2	28·27	29 75
Pyridine		0·3005	40·0	47·19	46 75
Quinoline.		0·3632	31·3	30·58	29·96

(*b*) Anhydrous salt.

Chlorine Determinations with Standard Sodium Hydrate Solution.

For this purpose 0·1—0·4 grm. of the double chloride was accurately weighed into a beaker and dissolved in 20 - 60 cc. of water, if necessary by warming. One or 2 drops of phenolphthalein solution were added to the solution, which was then titrated with a decinormal solution of sodium hydrate.

From the volume of alkali solution required to neutralise the hydrochloric acid liberated the percentage of chlorine in the salt was calculated.

The results obtained are given in Tables I. and II. It will be seen that they approach the theoretical values almost as closely as the determination with silver nitrate.

THE

HYDRIDES OF THE METALLIC ELEMENTS.

By J. FREDERICK CORRIGAN

(Concluded from p. 260).

General Properties of the Hydrides.

THE hydrides, with one or two exceptions, are generally obtained as amorphous solids resembling the metals in general physical properties. This is especially seen to be true if the hydride is derived from the finely-divided metal. The compounds departing from this observation are chiefly the hydrides of tellurium and antimony, which are gaseous, and, on account of their comparative ease of preparation, have long been known.

Tellurium Hydride, H_2Te (Hydrogen Telluride, Telluretted Hydrogen).—Tellurium hydride may be prepared by the direct combination of the elements by heating metallic tellurium in hydrogen:—

$$Tl + H_2 = H_2Tl.$$

It may also be prepared by the action of hydrochloric acid upon zinc telluride:—

$$ZnTl + HCl = ZnCl_2 + H_2Tl.$$

Berthelot and Fabre (*Ann. Chim. Phys.*, [6], xiv., 103—106) have obtained the gas in the pure state by the action of a very dilute solution of hydrochloric acid upon magnesium telluride.

Properties.—Tellurium hydride is a most offensive smelling and highly poisonous gas. According to Berthelot, however, the effects of breathing the gas are far less unpleasant than the selenium analogue, H_2Se.

The gas is very unstable, decomposing in a few hours, when confined over dry mercury, and almost immediately in the presence of moisture. It is unstable even at 0°, and rapidly decomposes on heating and also under the influence of light.

It is very similar in its chemical properties to the non-metallic hydrides of sulphur and selenium, and it precipitates the metals as tellurides from solutions of their salts.

In the pure state it is absorbed by alkalis, yielding white crystalline tellurides. If a trace of oxygen be present, however, violet or purple compounds are obtained, and if oxygen be present in excess metallic tellurium is deposited (Berthelot).

The gas is soluble in water, and the solution gradually absorbs oxygen from the air, depositing metallic tellurium.

Antimony Hydride, SbH_3 (antimoniuretted hydrogen, stibine), was discovered in 1837 by Lewis Thompson.

It is found when a solution of an antimony compound is introduced into a mixture generating hydrogen, such as zinc and sulphuric acid.

The formation of traces of this compound, and its subsequent decomposition by heat, or by combustion in a limited supply of air, is the basis of the celebrated "Marsh's Test" for antimony and arsenic. The substance suspected to contain antimony or arsenic is intro-

duced into a flask containing a mixture of zinc and sulphuric acid. The escaping gas is ignited, and the flame allowed to impinge upon a cold porcelain substance. If antimony or arsenic be present a brown or black stain will be deposited. The arsenic deposit is readily soluble in a solution of calcium hypochlorite, and thus the antimony deposit can be readily distinguished from it.

Antimony hydride is best obtained pure by the action of dilute sulphuric acid upon an alloy of antimony with zinc, calcium, or magnesium. The gas is passed through a U-tube immersed in liquid air, when the antimony hydride condenses to a white solid, whilst the hydrogen passes on.

Properties.—Antimony hydride is a colourless offensive smelling and poisonous gas, resembling the corresponding arsenic hydride in its general behaviour. When strongly cooled it condenses to a liquid, boiling at $-17°$, and when further cooled to a white solid, melting at $-88°$. It burns with a violet coloured flame, forming water and antimony trioxide.

$$4SbH_3+CO_2 = 6H_2O+Sb_4O_6.$$

It is easily decomposed by heat, and a black deposit of metallic antimony is obtained when the gas is passed through a red-hot tube. When electric sparks are passed through the gas it explodes violently.

Antimony hydride is decomposed by the halogens with the formation of the halogen hydride and the antimony halide.

$$SbH_3+3Cl_2 = 3HCl+SbCl_3.$$

It is also decomposed by concentrated sulphuric acid.

Hydrogen sulphide, under the influence of light, converts antimony hydride into antimony trisulphide.

$$SbH_3+3AgNO_3 = 3HNO_3+SbAg_3.$$

This reaction is sometimes used as a distinguishing test between antimony hydride and its arsenic analogue.

Composition.—The composition of antimony hydride may be determined by sparking the gas. Antimony is deposited, and three volumes of hydrogen formed.

$$\underset{\text{2 vols.}}{2SbH_3} = \underset{\text{Solid.}}{2Sb}+\underset{\text{3 vols.}}{3H_2}.$$

By passing the gas over hot weighed copper oxide and weighing the resulting copper antimonide formed, the formula is found to be represented by $(SbH_3)_n$. The vapour density of antimony hydride is 123·6 (H=1). Thus the formula of the compound is represented by SbH_3.

Hydrides of Copper.—Besides possessing the property of occluding hydrogen copper is remarkable in forming three distinct hydrides.

Cuprous Hydride, CuH_2.—Cuprous hydride is a well known compound, and it was discovered by Wurtz in 1844. It is deposited as a brown precipitate when a solution of copper sulphate is treated with hypophosphorous acid or its sodium salt.

$$3NaH_2PO_2+4CuSO_4+CH_2O =$$
$$= 3H_3PO_4+H_2SO_4+3NaHSO_4+2Cu_2H_2.$$

The formation of this compound constitutes a characteristic reaction for hypophosphites.

It is fairly stable at ordinary temperatures, but is decomposed on heating above 70°. It is also decomposed by the halogens and the halogen acids.

Cupric Hydride, CuH_2.—Cupric hydride is produced by the regulated action of heat upon cuprous hydride. It is obtained as a chololate-brown powder, which acts as a strong reducing agent, converting potassium chlorate into potassium chlorate, and nitrates for nitrites, and, in some cases, even to ammonia.

A. Léduc (Chemical News, 1891, lxiv., 61) describes the properties of "a new hydride of copper" which "has nothing in common with that discovered by Wurtz, which is destroyed at 60°." This hydride is obtained by the direct union of the elements at red-heat. It is described as "a body of a fine hyacinth-red colour" in which the hydrogen is actually combined, not occluded with the metal. It is stable at ordinary temperatures, and only presents mere traces of dissociation even at cherry-red heat.

The Hydrides of the Alkali Metals.—The alkali hydrides are formed by the direct union of the metals at red-heat. Potassium and sodium hydrides are obtained as silvery white compounds having a metallic lustre. They are soft at ordinary temperatures, and their fusion-point is lower than that of the metal. They are unstable in moist air, and they are rapidly decomposed by water, forming the hydrate of the metal and liberating hydrogen. Potassium hydride is spontaneously combustible.

Lithium hydride, however, is very stable in air, differing greatly in this way from the hydrides of sodium and potassium (M. Guntz, Chemical News, 1896, lxxiv., 271).

The alkali hydrides may be melted in an atmosphere of hydrogen without undergoing any decomposition, but at 330° they begin to evolve hydrogen, and at higher temperatures the whole of the hydrogen is given up.

In this way Troost and Hautefeuille (*Ann. Chim. Phys.*, 1874, [5], ii., 273) determined their composition. One volume of sodium hydride evolved 237 volumes of hydrogen, being practically the volume required for the formula Na_2H.

According to later authorities, however, the formulæ K_2H and Na_3H, given by L. Troost and P. Hautefeuille, are considered to be erroneous.

Alkaline Earth Hydrides.—The hydrides of the metals of the alkaline earths may be obtained in the same manner as the alhali hydrides, and they were first prepared in the pure state by H. Moissan. (Chemical News, 1898, lxxviii., 157; 1900, lxxxi., 131), and later by Dupont and R. Mitlawe (*Journ. Chem. Soc.*, 1914).

They have the formula of the type CaH_2; and, like the hydrides of the alkaline metals, they readily decompose water, forming the hydrate of the metal, and liberating hydrogen. $CaH_2+2H_2O = Ca(OH)_2+2H_2$.

At ordinary temperatures, and in dry air, they are fairly stable bodies, of a white or greyish white colour, and they act as energetic reducing agents.

They take fire when heated to redness in pure dry oxygen, and when heated strongly in an atmosphere of carbon dioxide, the latter is reduced, with the formation of calcium carbide and free carbon.

They are decomposed by the halogens with the formation of the halogen acid,—

$$CaH_2+Cl_2 = Ca+2HCl.$$

They reduce warm sulphuric acid, giving reduction products varying with the temperature and concentration of the acid, and they are slso attacked by hydrochloric acid. Nitric acid, however, is said to have practically no action upon them.

When equal volumes of hydrogen and nitrogen are passed over the heated alkaline earth hydrides, imides are formed, having a formula of the type Ca = NH. These imides are more or less unstable, and they darken on exposure to light. Calcium imide is the one most easily prepared, but it has not yet been obtained in the pure state. The formation of barium and strontium imides is incomplete.

The Hydrides of the Rare Earth Metals.—The hydrides of the rare earth metals are obtained by the direct union of the elements at red heat, or by passing pure dry hydrogen over a heated mixture of magnesium powder and the metallic oxide. In the latter reaction, the oxide is first reduced to the metal, which then combines with the hydrogen:—

$$RhO_2+2Mg = Rh+2MgO,$$
$$Rh+2H = RhH_2.$$

The formation of these compounds has been studied chiefly by Matignon, who has obtained the hydrides of beryllium, cassium, cerium, erbium, gallium, lantha-

num, neodymium, niobium, praseodymium, rhodium, rubidium, germanium, yttrium, vanadium, and zirconium. (*Chem. Zeit.*, 1900 [97], xxiv., 1062; *Comptes Rendus*, 1900, cxxxi., 891; Chemical News, lxxxii., 303).

Many hydrides of the rare earth metals have also been described by Winkler (*Ber.*, 1891, ccxliv., 888) and Muthmann and Kraft (*Annalen.*, 1903, cccxxv., 281).

The hydrides of the rare earth metals are usually obtained as amorphous substances, varying in colour from white to black, and containing more or less of the finely divided metal, and the metallic oxide as impurities.

Many of them are stable in dry air at ordinary temperatures, and they generally decompose water with the evolution of hydrogen. They evolve hydrogen when heated, cerium hydride, CeH_3, being explosively converted into cerium oxide and hydrogen.

Hydrides of the Radio active Metals.—The hydrides of thorium and uranium can also be prepared by Matignon's method, which has already been described, but the existence of a definite hydride of radium is at present very doubtful and uncertain.

Lawson (*Journ. Chem. Soc.*, 1916), in the course of a determination of the range of the α particles emitted by Polonium in an atmosphere of hydrogen, found that the ionisation current at a given distance gradually increases with the time. In explanation of this effect, he supposes that a volatile hydride of polonium is formed, which is rapidly decomposed by the ionised gas.

The existence of other hydrides, such as those of palladium and platinum, has been postulated in order to account for the phenomenon of occlusion of hydrogen by those metals. Although numerous attempts have been made to isolate and purify definite compounds of these metals with hydrogen, the results obtained have been very unsatisfactory, and pure palladium and platinum hydrides have not yet been obtained. When iridium, however, is subjected to long continued cathodic pulverisation, it absorbs about 800 times its volume of hydrogen, probably with the formation of a hydride. This hydride, however, has not yet been isolated and determined.

Silver and lead form hydrides when the finely divided metals are heated with magnesium powder in an atmosphere of hydrogen.

Berthelot (*Comptes Rendus*, cxxxi. [26], 1169-1170) has prepared a hydride of silver by heating the metal in the finely divided state, in a heated tube containing hydrogen at 500—550°.

M. J. Bouffort (*Journ. Soc. Chem. In.*, 1909, xxviii., 1126) has prepared a lead hydride by immersing magnesium in a solution of lead acetate in the cold. The metal becomes coated with a thick spongy layer, which is said to contain a hydride which possesses all the properties of the one prepared synthetically.

Application and Uses of the Metallic Hydrides.

The application and uses of the metallic hydrides are practically nil, and it is only for theoretical interest that they are prepared.

E. W. Morley (1895), in his work on the determination of the composition of water by weight, obtained pure hydrogen by heating the hypothetical palladium hydride, obtained by the action of hydrogen, under slight pressure, upon palladium.

From time to time, suggestions have been brought forward for the utilisation of certain hydrides for the commercial production of hydrogen. Attempts have been made for this purpose, but have generally failed, owing, perhaps, to the great uncertainty and difficulty of obtaining the hydride pure enough. A preparation of calcium hydride has been used for the commercial production of hydrogen. It is sold under the name of "hydrolith." By simply treating hydrolith with water, hydrogen is evolved, which is sufficiently pure for all practical purposes.

With more interest and closer study of the conditions under which the metallic hydrides are produced, and also of their reactions, greater knowledge of their production and properties may be gained, and thus a spur may be given to their utilisation in commercial synthetical processes, as has been the case with their companion compounds—the nitrides.

USE OF ELECTRICITY IN AGRICULTURE.*

With Special Reference to its Development in Germany.

By JOHN FRANCIS CROWLEY, D.Sc., B.A., M.I.E.E.

(Continued from p. 265).

Applications.

Some applications of electricity on the farm are of sufficient importance to merit special description, and under this heading may be classed electricity applied to ploughing and to threshing. In connection particularly with the former, considerable technical skill has been displayed in the design of suitable apparatus to meet conditions in the field, and much success has been achieved.

Several of the larger electrical manufacturing firms actually design and manufacture ploughs suitable for working with the electrical apparatus they supply.

Ploughing by means of electricity has latterly made considerable progress in Germany, but its progress at the beginning was slow. The power required for this class of work is fairly considerable, and many of the smaller power-stations were unwilling to accept the load. Now, however, central stations of considerable size have been erected in most areas, and consequently development have been rapid. To enable central stations to develop and supply energy at a cheap rate, it is important that their load should be evenly distributed throughout the year, and the development of electric ploughing in agricultural districts help the central stations distributing in rural areas to maintain this even distribution.

Ploughing, it is generally found, can be so arranged in connection with other classes of farming work that when the electric ploughs are in use other electrically-driven machines are either not in use or only partially employed, and by this means the load is averaged during the periods of working.

Mechanical ploughing is generally carried out either (*a*) by means of tractors, in which case the motor, whether operated by oil, steam, or electricity, moves with the plough across the field to be ploughed; (*b*) by means o stationary motors placed one at each side of the field to be ploughed, with a single steel cable traversing the distance between them, the plough being hauled in one direction by one motor and in the other direction by the other; or (*c*) by means of a single motor placed at one side of the field and a winch at the other, the plough being moved from one side of the field to the other by a steel cable which passes from cable drums on the motor round the winch.

Tractors operated by oil and steam have come much into use of recent years, but electrical tractors have scarcely emerged from the experimental stage.

Electric Tractor Ploughing.—The most practical attempt to provide an electric tractor was that of Zimmerman, who placed anchors at each side of the field to be ploughed, with a stretched chain between them. A large plough, of the type used in the Fowler system, carried an electric motor, which engaged, by means of cog gearing, with the chain and so moved the plough across the field. The chain anchors were moved forward when necessary, and current was supplied to the motor by means of an insulated cable carried on suitable supports and connected to a transformer wagon. This system has not been very successful, and has only been used for light work.

* Reprinted by permission from the *Journal of the Royal Society of Arts.*

Ploughing by two stationary motors, or a stationary motor and winch, has, on the other hand, found much favour with electrical engineers, and several continental firms have put excellently-designed apparatus suitable for these systems on the market.

Two distinct types of apparatus have been developed—one of a heavy type, manufactured principally in Germany, and latterly also in France, and the other of considerably lighter construction developed in France. It may be said that the heavy type has so far been the more successful, and that its best development has been in Germany, where the Siemens winch and winding wagons, described in this paper, are much in use.

Double Winder Ploughing.—In this system of ploughing two winding wagons, generally similar in design, are placed one on each side of the field to be ploughed. Each winding wagon, typical examples of which are illustrated in Fig. 11, carries an electric motor, the necessary switchgear, mechanical gear, and the plough cable haulage drum. The working weight of the type illustrated, which is of the heavy German pattern, including wire rope, but without cable, is about 13,000 kgrms. Some dimensions are given in the following table:—

	Length. Metres.	Width. Metres.	Height. Metres.
Overall dimensions.. ..	6·60	2·60	3·03
Wheels, front	—	0·33	1·30
Wheels, back	—	0·50	1·80

The wagon consists of a strong framework strengthened in suitable places by cross and longitudinal members and supported at the rear by the back wheels and at the front, through a strong steel pivot over a beam, by the front wheels in a manner already described for motor wagons. It is thus always supported at three points, namely, the two back wheels and the pivot of the front beam, and thus all twisting and straining are prevented and the framework is not affected by the unevenness of the ground. The steering of the wagon is done from the driver's position in the motor compartment by turning a hand wheel in the direction in which it is desired to go. The neutral position of this wheel, on which the wagon will move straight forward, is indicated by a special mark. The front wheels are fixed in the manner usual to motor-car practice, so that the steering is done by the movement of the wheels and not by the rotation of the front axles.

In one design of this winding wagon the front part is fitted with a locked driver's cabin, which encloses both the electric motor and the steering gear, while the rope drum at the back of the wagon and the mechanical gearing are protected against rain, snow, &c., by a plain metal roof. In another design the driver's cabin, which, as in the previous case, contains the electrical equipment, is replaced by a plain roof covering the whole wagon.

A strong break is provided which can be applied both from the rear of the wagon and from the driver's cabin by means of a foot lever, which is interlocked with the electric switch, and so cuts off the electric current if any hindrance or danger suddenly occurs curing the ploughing or during the back and forward movement of the wagon itself.

To enable the wagons to progress better on soft and slippery ground, special attachments can be made to the back wheels, and cutting flanges are sometimes fastened to the front wheels to prevent the front of the wagon being pulled round. The length, width, and height of the wagons are such that they can conveniently be loaded on to an ordinary flat railway bogie, and Fig. 11 shows such wagons arranged for railway transport on a bogie.

On good roads the winding wagons can be moved by six or eight horses, and for this purpose a strong shaft is fastened to the pivoted beam at the front of the wagon and so connected that the steering of the wagon is not done by the steering wheel, which is disconnected, but by the movement of the shaft. Under difficult conditions of transport, as on slopes or sandy ground, the wagon can be moved by fastening one end of the haulage cable to the ground at a suitable point, coupling up the motor mechanically to the cable drum as for hauling the plough and pulling the wagon backwards and forwards as may be desired.

(To be continued).

INERTS UPON THERMAL EFFICIENCY IN COAL GAS.

THE question of efficiency and the effect of inerts upon the thermal efficiency in the use of coal gas was discussed by gas engineers and chemists on Thursday, December 4, at a meeting in Birmingham of the Midland Junior Gas Association.

The author of the paper, Mr. James W. Wood, M.Sc., A.I.C., Research Chemist, Fuel Department, Leeds University, pointed out that the question of inerts is one which has been discussed upon several occasions during the past three or four years by the Midland Gas Association. The Gas Investigation Committee of the Institution of Gas Engineers, through the medium of its Research Sub-Committee—a Joint Committee of representatives of the University of Leeds and of the Institution—have been subjecting the same question to experimental investigation. On the subject of efficiency testing in general, although we may travel a considerable distance with certainty by means of our knowledge of the physical, thermal, and chemical properties of gases, it is found that, even in the simplest uses to which towns' gas is applied, the available data are not sufficiently complete to enable one to say beforehand what will be the exact result in any but a few cases. Several theories which receive support in different quarters fail to agree with the observed facts, not because they are fundamentally wrong, but because they account for only part of the phenomena attendant upon the combustion of gas; indeed, this estimation of the relative importance of the different factors involved is a most difficult matter. The phenomena are, as a rule, so complex that appeal to experimental inquiry is the only satisfactory course.

Until comparatively recent times one could not have made the statement without serious opposition; but the trend of opinion to-day is that the majority of gas consumers desire to purchase, not gas, but energy in the form of heat units or B.Th.U., and this is the key to the proposed regulations for the control of gas quality. The number of heat units taken by the consumer is obviously the product of the calorific value of the gas and the number of cubic feet supplied. Strictly speaking, however, gas undertakings do not supply heat units, but only the means of generating heat units; and if the consumer fails to generate the whole of the potential heat units supplied to him, or, having successfully generated them, fails to apply them properly, a loss of efficiency will be entailed.

At one time it was expected that, as the result of the labours of the Gas Investigation Committee, it would be possible to say that a gas of such and such composition and calorific value would yield the highest thermal efficiency in use, and that other gases could then be assessed according to the closeness with which they approached this quality. This expectation must now be entirely abandoned. The exigencies of war and of strikes have caused experiments to be made with different qualities of gas on a scale that would barely have been contemplated by the most unorthodox of gas managers. It cannot, however, be said that all the grades of gas supplied have been equally satisfactory—in fact, some are most undoubtedly unsatisfactory. Nevertheless, careful tests show that a reasonably high thermal efficiency is attainable over a very wide range of composition and calorific value. Moreover, thermal efficiency is not the only efficiency to be considered, and cost of production,

type of plant, and nature of the coal available as raw material will influence the quality of gas produced for the best all round efficiency.

The stagnating and restrictive effects of the old illuminating power standards are so well known that it is almost superfluous to point out that in any new regulations which are framed the gas quality should not be controlled by its application to one particular use, to the exclusion of all others, although reasonably good performance is to be expected in any use to which gas is applied. Whatever local conditions shall decide as to the most economical grade of gas for a particular district, uniformity of quality for the district cannot be too strongly emphasised. The means of adjustment to appliances provided by the makers are rarely sufficient to cope with wide variations in gas quality, and in any case there is usually some difficulty in explaining the precise function of an adjustment to a non-technical user. The only rational course is to send out the appliances from the gasworks properly adjusted to give the highest thermal efficiency with the local gas under normal conditions or to employ an efficient visiting maintenance staff. In either case uniformity of the product sent out from the gasworks is essential if such adjustments are to be satisfactory and permanent—*i.e.*, there should be no necessity for frequent readjustment of the kind involving the use of skilled labour.

As to the addition of air to coal gas, such air contributes nothing to the calorific value, and, so far as specific gravity and calorific value per cubic foot of "gas" distributed is concerned, may be regarded as substantially the same in effects as an equal volume of nitrogen. For those appliances which fail to give satisfactory aeration with rich gases, such as straight coal gas, it would seem to be an obvious remedy, for the demands for primary aeration will be reduced by the amount of air added. In adding air, we are not adding anything to the gas which would not be finally mixed with it before combustion was completed, and therefore the flame temperature would not be reduced by such addition.

When subjected to actual test it is found that the addition of small amounts of air to straight coal gas does improve the thermal efficiency if conditions are such that the appliance was formerly suffering from defective aeration. Beyond the point at which the burner itself is capable of injecting all the air required, however, no advantage is gained by the addition of air. It must also be taken into account that there are risks attendant upon the mixture. It is not suggested that any undertaking would send out gas-air mixtures nearing the explosive limit; but there is always the possibility of failure of the mechanism regulating the admixture of gas and air, in which case local irregularities or "streakiness" of the gas mixture may occur, parts of which may reach the danger limit. Also in the presence of CO_2, water vapour, oxygen, and a fluctuating temperature we have all the factors present for vigorous corrosion and stoppage of meters and services. Upon the ground of thermal efficiency in use, this addition of air may be justifiable; but on all other grounds it is best excluded. Further, conclusions with regard to "inerts" which are based upon the addition of air to coal gas will not agree with those based upon the addition of inerts other than air, since the effects upon the combustible mixture are totally different. This calls for caution in interpreting results given as demonstrating the influence of inerts upon the behaviour of gases where the character of the inerts as well as their quantity are subjected to variation at the same time.

The admission of inerts to a gas is practically unavoidable, and to a certain extent is commercially advantageous, because the ingress of a definite amount of inerts at the retort means less likelihood of loss of valuable coal gas to the settings. Given suitable burners, the improvements as regards thermal efficiency in use brought about by the reduction of inerts from (say) 10 per cent to 5 per cent would probably be more than counter-balanced by the extra cost of working to secure this end. Further, many existing burners could not use the gas with 5 per cent inerts to as great advantage as that with 10 per cent inerts; and therefore the point of producing the richer gas is largely discounted. There seem to be considerable advantages in reducing the calorific value of a gas, provided this is done in such a way as to be conducive to coal conservation. There is, however, no coal conservation effected by the reduction in the calorific value of coal gas by the introduction of inerts in quantity. Unless a sliding scale were arranged which favoured gases of low calorific value, there would be no commercial advantage in increasing inerts when selling on a B.T.U. basis. The limits as regards inerts which would be reached with reasonably good working for straight coal gas practice are, in all probability, lower than is actually permissible before the thermal efficiency in use is so reduced as to be prohibitive—at least, as far as domestic use is concerned.

On the whole, therefore, if selling upon a B.T.U. basis, it would seem to be the best practice commercially to restrict inerts in otherwise straight coal gas practice, quite apart from any legal compulsion in the matter, and if the calorific value of gas is to be seriously reduced it is fundamentally wrong to bring about this reduction by the use of excessive quantities of "inerts."

Mr. Carrington Barber (President), Birmingham, pointed out that recent reduction in the quality of gas was not a recommendation by the Government either for commercial or increased efficiency, but an emergency order for the conservation of coal, and therefore the results obtained must not be taken as indicative of the utility of low calorific value gas, since the reduction was brought about mainly by the introduction of inerts and not by blue water gas.

A discussion followed.

COLLEGE OF TECHNOLOGY EXTENSIONS.

The fact that the provision for University education in England is only one-half of the provision in America, and only one one-third of what it was in Germany before the war, is explained in an appeal for £150,000, which has recently been made by the College of Technology. The English Universities are full and urgently need extending. Moreover, the American superiority is increasing, for Harvard University has collected 12 000,000 dols. during the last three months, and during one month of the same period the neighbouring Massachusetts Institute of Technology has collected 10,000,000 dols. for the extension of their work, so that altogether some four and half million pounds sterling has been subscribed for the extension of university education in Massachusetts, and of this nearly one-half is devoted to Applied Science and Technology.

With a view to the extension of the provision of university education in the Manchester district, two appeals are being placed before the public, the one for £150,000 for an addition to the buildings of the College of Technology and the other for £500,000 for various purposes connected with the other departments of the same University of Manchester. If Massachusetts can find more than £4,000,000 for the extension of university education in Boston, Lancashire will surely find the £650,000 needed for the extension of university education in Manchester.

The College of Technology is especially concerned with university education, including research and the training in methods of research in Applied Science and Technology, and this is the department of university education in which the provision in England is furthest behind that of America and some other countries. The special need for remedying the deficiency so far as Manchester is concerned is explained in the appeal. It is further explained that the need can be economically met by the proposed extension

of the College of Technology; for in the first place the proposed new building, although only one-third the size of the present building, will practically double the accommodation for undergraduates, and more than double the facilities for research. Moreover, the new building, which will cost £150,000, will stand on a site for which £44,000 was paid some twelve years ago, and will be equipped by the Governing Body at a cost approximately of £50,000, so that the building with its equipment and its site will be worth nearly £250,000. The cost of maintenance is also guaranteed. The result is that Lancashire industries by subscribing £150,000 for the new building will actually benefit to the extent of £250,000 (or, if the cost of maintenance capitalised as an endowment be added, to an extent of something like three-quarters of a million).

The Appeal has been commended, and the need for the extension of the College buildings has already been urged by several of the leaders of the Textile, Engineering, and Chemical industries in Lancashire. The most recent and representative opinion was recently expressed at a meeting of the Executive Committee of the Manchester Branch of the Federation of British Industries, when the following resolution, moved by Sir Herbert Dixon and seconded by Sir Edward Tootal Broadhurst, was carried unanimously:—

"That having regard to the fact that the Manchester College of Technology was the first technical institution of university rank to be established in this country, and being firmly of opinion that the development of the invaluable work of the College of Technology is of vital importance to the well-being of the industries of the District and County, this Executive Committee of the Manchester District Branch of the Federation of British Industries, confidently commends the appeal for £150,000 (of which £26,000 has been promised absolutely and conditionally) to extend the College of Technology to the sympathetic consideration of all Lancashire producers, being of opinion that lack of whole-hearted support will be to the prejudice of Lancashire industry."

Subscriptions, which should be made payable to the College, may be addressed to the Principal, College of Technology, Manchester.

PROCEEDINGS OF SOCIETIES.

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS.

Ordinary Meeting, December 3, 1919.

Dr. Samuel Rideal, President, in the Chair.

A Certificate was read for the first time in favour of Mr. William John Read, M.Sc., F.I.C.

Certificates were read for the second time in favour of Messrs. Percy Ewart Bowles, F.I C., Ph.D (Heidelburg); Charles Crowther, M.A. (Oxon), Ph.D. (Leipsic); John William Hawley, B.Sc. (Lond.), A.I.C.; Ernest Joseph Lush, B.A. (Cantab), A.I.C.; H. Percy Marks, B.Sc., A.I.C.; Robert Selby Morrell, M.A. (Cantab), Ph.D. (Wurzburg), F.I.C.

The following were elected members of the Society:— Messrs. William Norman Long, John Dalton.

The following papers were read:—

"*New Distillation Method for Detecting Adulteration in Butter and for Estimating Fats of the Coconut Group.*" By George van B. Gilmour, B.Sc., A.R.C.S., A.I.C.

The method consists in separating the volatile acids into two groups depending on their solubility or insolubility in saturated brine, NaCl. Results are given for the application of the method to the distillate from the Blichfeldt apparatus. These results indicate that the composition of a fatty mixture deduced in this manner is more reliable and more rapidly obtained than by the combination of the Reichert-Meissl-Polenske-Kirschner method.

"*A New Process for the Determination of Arsenic; with Notes on the Chemistry of the Marsh-Berzelius Process.*" By B S. Evans, M.C., B.Sc., F.I.C.

Arseniuretted hydrogen evolved by reduction with zinc and sulphuric acid is decomposed by ignited copper. The increased weight of copper is divided by a factor which is discussed. The necessity is shown for the absence of heavy metals. The retention of arsenic in the Marsh-Berzelius test is considered to be due to (*a*) metallic arsenide, (*b*) arsenic. The author also puts forward an explanation of Chapman's modification using cadmium.

INSTITUTION OF MINING AND METALLURGY.

Ordinary Meeting, November 20, 1919.

H. K. Picard, President, in the Chair.

"*A Contribution to the Study of Flotation.*" By H. Livingstone Sulman.

After giving a brief historical review of the development of flotation as applied to ore extraction, with the problems that arose in connection with successive phases of the process, the author dealt principally with froth flotation, which he characterised as the final link in a long chain of effort. The essentials of this process are that an aqueous pulp shall be agitated with certain reagents which may be classified as a "froth-producing" material, a "froth-stabilising" substance, and a "gangue modifying" addition. The explanation of flotation may be based on the differences shown by various substances in the degree to which they are "wetted" by water and other liquids. Wetting is a condition of wide variability, and a theory of flotation must be based largely upon the physics of wetting. The degree of wetting may be influenced by the molecular porosity of the solid surface, and indicated more or less quantitatively by the "contact angle" made between the free surface of the liquid and that of its interface with the solid. Reviewing the various problems encountered in dealing with flotation the author devoted considerable attention to the molecular constitution of liquids and solids, gravitation and molecular forces, surface energy and surface tension, interfacial tension which involves consideration of the effects of complete wetting and differential wetting, hysteresis, adsorption, the *rôle* played by immiscible oil, and the action of modifying agents such as acids. In this last connection the theories of flocculation and deflocculation have to be taken into account, including their electrical relationship. Film flotation and differential flotation receive separate attention. The author's general summary gives prominence to the following findings:—Flotation reactions result from the molecular forces acting at the surfaces of solids and liquids; these arise from unbalanced molecular attractions in the surface-layers, which in turn are in functional relation to the balanced molecular attractions constituting cohesion for a solid or a liquid. Every solid or liquid therefore possesses excess energy, which may be exhibited in adhesion effects. Liquid-solid adhesion is broadly reciprocal to interfacial tension. The degree of wetting can be relatively quantified within certain limits by the contact angle made between the free surface of the liquid and that of the solid. Contact angles have a minimum and maximum value; the angular difference between these values is the hysteresis of the contact angle, which permits a wider range of equilibrium for a floating particle. The dynamical aspect of the subject is concerned with the molecular constitution of the interfaces, with the kinetic effects of molecular motion at the surfaces and interfaces of solids and liquids, and with those in the interior of liquids. Solid surfaces are probably penetrable by the

molecules of liquids, which enhances the adhesions between them; such penetrations may give rise to a persistent tendency for the solid to be again wetted by the same liquid. Concentration of foreign molecules at the surface of a pure or homogeneous liquid (positive adsorption) reduces the surface tension of the liquid and confers upon it the property of "frothing." Frothing reagents useful in flotation produce a froth with water, yet leave a partial strain (mineral adsorptive energy) at the bubble surface. The mineral adsorption now stabilises the film, especially if the mineral be minutely oil-filmed; still more so if flocculated. To be employed effectively the bubble system must be disseminated throughout the mass of ore-pulp. When water-strain is completely removed from the surface of suspended particles, deflocculation results. Flocculation is greatly increased by mechanical agitation, by minutely oiling the particles, and by contact with air; these are factors necessary to produce standard mineralised froths. Generally, if a substance can be flocculated it can be floated. Electrical phenomena are concomitants of minor order. Flotation depends in bringing about the most advantageous selective adhesions, selective adsorptions, and selective flocculations between the complex of particles in an ore-pulp.

INSTITUTE OF CHEMISTRY.

Annual Meeting of the Birmingham Branch.

The Annual Meeting of the Birmingham Branch of the Institute of Chemistry was held on Monday, December 8, at the rooms of the Chamber of Commerce, Birmingham, Dr. E. W. Smith (Chief Chemist, Birmingham Gas Works) presiding.

The Annual Report, read by Mr. F. C. A. H. Lantsberry, M.Sc., Hon. Sec. (Birmingham Small Arms Co.), stated that since its inauguration in November last year the Birmingham Section had done excellent work. From the outset the Committee decided that in matters of technical and scientific interest it would co-operate with the Birmingham and Midland Section of the Society of Chemical Industry, and would largely devote the attention of the Section to discussion of professional matters, and to the organisation of the local qualified chemists. Five meetings had been held, and the following subjects were discussed:—"The Remuneration of the Qualified Chemist" (opened by Mr. S. C. Farrar), "The Training of the Works Chemical Staff" (opened by Dr. E. W. Smith), "State and Municipal Aided Laboratories and the Professional Chemist" (opened by Messrs. H. Silvester and A. E. Tucker), and "The Relation between the Chemist and Engineer" (opened by Mr. Lantsberry).

The Committee had arranged to hold a joint dinner with the Local Section of the Society of Chemical Industry; this would take place early next year.

Mr. S. C. Farrar had resigned from the Committee consequent upon his removal to Scotland, and Mr. Rossiter, Dr. Parker, and Mr. Webb retired, and were not eligible for re-election.

With the Committee's approval the Council of the Institute appointed Prof. Frankland (late of the Birmingham University), Mr. H. Silvester, Dr. Twiss (Dunlop Co.), Dr. Smith, Mr. F. R. H. O'Shaughnessy (Consulting Chemist, Tame and Rea Drainage Board), and Mr. Lantsberry to act as a Committee to interview local applicants for admission to the Institute without examination, and to advise the Council as to their suitability for election.

The Committee had interviewed a number of candidates. Prof. Frankland had expressed his desire not to act on the Committee, and the Committee had requested the Council to add the names of Prof. Morgan (University of Birmingham) and Dr. Slater Price (Birmingham Technical School) to the Committee.

The number of members of the Institute who had definitely joined the Local Section stood at 50. This was to be regarded as satisfactory for the first year of working, but the Committee hoped there would be a good influx of members in the near future.

The financial statement showed a small balance in hand.

The report was unanimously approved.

Mr. N. P. Booth and Mr. S. R. Carter were appointed to the Committee, two other vacancies to be filled later; and on the motion of Mr. H. T. Pinnock, seconded by Mr. H. Silvester, Mr. Lantsberry was unanimously re-elected hon. sec.

Mr. Lantsberry stated that there were about 140 members of the Institute of Chemistry in the Birmingham and Midland district, and it was hoped that a large proportion would join the Local Section.

Prof. T. Turner (Chair of Metallurgy, University of Birmingham) suggested that members of the Committee undertake to interview chemists with a view to increasing the membership, and the meeting approved this suggestion.

Mr. Lantsberry said he was confirmed in the belief that when district representatives were elected to the Council there would be a big accession of members to local sections.

As to general policy, Dr. Smith stated that the Institute Committee had agreed that the Society of Chemical Industry should deal with all technical matters. It was the business of the Institute to take in hand matters of professional and social interest to chemists.

Mr. Silvester thought it might be well to hold three or four meetings, mainly social; but if necessity arose for the discussion of chemical politics other meetings could be arranged.

Mr. N. P. Booth urged the importance of providing facilities by which chemists could meet in friendly intercourse.

The Chairman said chemists would be less diffident about discussing economic questions when they knew one another better.

Dr. H. W. Brownsdon (Kings Norton Metal Co.) said he believed that the members of the Section would increase when its work was better known.

Mr. Silvester thought the present body might be asked to publish the reports of the local sections.

The Chairman said he was fully persuaded that the time had come when industrial chemists would be compelled to work together more. He was a strong believer in organisation.

Mr. Pinnock said chemists needed to humanise themselves; there should be less of the spirit of isolation. It was necessary to dispel what seemed to be a common notion that the love of chemistry was to the chemist largely his reward; consequently, financial considerations did not always receive sufficient attention from others.

The Committee undertook to formulate a scheme for the ensuing year.

NOTICES OF BOOKS.

Alcohol. Its Production, Properties, Chemistry, and Industrial Applications. By Charles Simmonds, B.Sc. Pp. xx+574. Macmillan and Co., St. Martin's Street, London. 1919. Price 21s.

We are of opinion that this volume, in which the author has included a large amount of valuable information, will prove exceedingly useful to all engaged in the production, testing, and commercial application of alcohol.

The first part of the book describes the various processes for the production of alcohol and the materials and biochemical agents used. The recently developed processes for obtaining alcohol by synthesis from acetylene are dealt with at some length.

The next section of the book contains a *résumé* of the general properties of the alcohols as a class, and gives the methods in use at the present time for the detection and estimation of ethyl and methyl alcohols when mixed and when in the presence of other bodies.

The section on the industrial applications of alcohol, describing the preparation of substances in which alcohol acts as the raw material or of which it is a constituent.

Alcohol as a source of heat, light, and power is discussed in the light of recent tests, and in an Appendix is given an extract from the report, issued in 1918, of a Commission set up to investigate this question.

The later portion of the book deals with the various methods in use for the chemical examination of beer, wines, and spirits, and gives a brief description of the general characters of each beverage with any special tests which may be applied to it.

In the Physiological Section is described the effect of alcohol on the various organs of the body and the modern opinions on its use in the treatment of fevers and as an antiseptic.

Chemistry from the Industrial Standpoint. By P. C. L. THORNE, B.A. Pp. xvi+244. London: Hodder and Stoughton, Warwick Square, E.C. 4. Price 4s. 6d.

THIS volume is one of the "New Teaching Series" published by Messrs. Hodder and Stoughton; it contains a preface by Dr. Briscoe.

The author endeavours to portray to the non-scientific mind the principles involved in the manufacture of some of the commoner chemical compounds.

The book is divided into five sections; the first, entitled "Solids, Liquids, and Gases," explains the distinction between these three states of matter, and the methods employed in practice for their separation from one another.

Section B explains a chemical change as distinct from a physical change, which is dealt with in the first section. It includes those processes wherein the manufacture of a substance is brought about by a chemical decomposition. Two chapters are devoted to the manufacture of "washing soda," firstly by the Leblanc process, and secondly by the ammonia-soda process.

The manufacture and properties of the most important non metals and their compounds is discussed in the next section.

Section D is entitled "The Rate of Chemical Change," and herein is described the use of catalysts; among the examples given are the contact process for the manufacture of sulphuric acid and the conversion of oils into solid fats.

"The Use of Electricity in Chemical Change" is the subject of the last section; the manufacture of compounds in the electric furnace, also by electrolysis, is explained.

The book is well interspersed with diagrams, and it is written in a style which should be thoroughly understood by those who have not been able to have a thorougb scientific education.

The Year Book of Wireless Telegraphy and Telephony. 1919. London: The Wireless Press, Ltd., Marconi House, Strand. Pp. cxiv+1160.

THE Year Book of 1919 contains the usual information invaluable to those interested in Wireless Telegraphy and Telephony and allied subjects. This is its seventh annual appearance and contains much information previously withheld by War censorship.

In the "Special Articles" section, contributions have been given by Dr. J Ambrose Fleming, Dr. W. H. Eccles, and other experts in this branch of science.

The "Tables" printed amongst "Useful Data" in former years have been printed in a separate book edited by Mr. Bertram Hoyle.

The other sections, including the "Biographical," "The Land and Ship Stations," &c., have all been brought up-to-date.

The Wireless Map of the World, in its duplicated mercator form has been brought up-to-date with a further hundred entries.

BOOKS RECEIVED.

"The Condensed Chemical Dictionary." Compiled and Edited by the Editorial Staff of the Chemical Engineering Catalog. First Edition. The Chemical Catalog Company, Inc., 1, Madison Avenue, New York. 1919. Price 5 dols.

"The Nature of Enzyme Action." By W. M. BAYLISS, M.A., D.Sc., F.R.S. Fourth Edition. Longmans, Green, and Co., 39, Paternoster Row, London. 1919. Pp. viii+190. Price 7s. 6d. net.

"Alcohol. Its Production, Properties, Chemistry, and Industrial Applications." By CHARLES SIMMONDS, B.Sc. Macmillan and Co., St. Martin's Street, London. 1919. Pp. xx+574. Price 21s.

CORRESPONDENCE.

SIR J. J. THOMSON'S THEORY OF ELECTRICAL CONDUCTION IN METALS. ABSTRACT AND COMMENT.

To the Editor of the Chemical News.

SIR,—May I take up a little space to give in abstract Sir J. J. Thomson's modification in the generally-stated theory of conduction in metals (for full particulars see *Inst. Elect. Engrs. Journ.*, 1907, lxxxviii., p. 455; or *Electrician*, lviii., p. 839), which may be of interest in connection with my notes on conduction recently published (see CHEMICAL NEWS, cxix., 14, 62, 199).[1]

It has been considered that the action of metallic atoms on each other sets free electrons which diffuse throughout the mass of the metal, the metal being porous to electrons, the free electrons being supposed to act as a perfect gas; and according to this theory, it was thought that the electrons remained free for a sufficient time to attain thermal equilibrium with the metal itself, so that, like all gases, the average kinetic energy of the electron was a constant merely depending upon the temperature.

According to Thomson's modification of the above theory the electric force is supposed to act on the electrons before they leave the atoms with which they are normally associated. Moreover, the atoms are supposed to act together as electrical doublets, the electrons flowing from the negative end of one doublet to the positive end of the other.

The experiments of Rubens and Hagen on conduction in silver under very rapid alternating forces indicate that the number of electrons per cubic centimetre would be $1 \cdot 8 \times 10^{24}$. This number of electrons in the times deduced is required to give the proper conductivity of silver. This evaluation introduces a difficulty, for, having obtained the number of conducting electrons, each of these possess at the absolute temperature θ an amount of kinetic energy $a\theta$, and therefore to raise the temperature 1° would give to each electron an energy a, or give energy to the total number $a \times 1 \cdot 8 \times 10^{24}$, a being about $1 \cdot 5 \times 10^{-16}$; so that this energy is $1 \cdot 8 \times 1 \cdot 5 \times 10^{8}$ ergs, which represents about 7 calories to raise 1 cubic centimetre of silver 1° C. if the electrons only are concerned. Now the actual energy required to raise the temperature of silver is only about 0·6 cal., so that there is a serious discrepancy between the results of the theory in this form and the results of specific-heat experiments.

This difficulty is overcome by supposing that the electron instead of darting about jumps straight from one atom to another, the conception of atomic doublets being introduced to facilitate this action.

With regard to the Hall-effect, Sir J. J. Thomson says:—"Suppose that we have a doublet with negative

and positive ends, then if it is pulled round by an electric force, the ends start moving, one in one direction and the other in the opposite, and if there is a magnetic force acting upon the thing at right angles to the plane of motion, then there will be forces acting upon these two ends. If the ends move with equal and opposite velocities, the forces on the two ends are equal; but if the velocities are different, then the forces on the ends are different and there is a couple produced—in fact, the doublet when placed in a magnetic field behaves exactly like a gyroscope. Suppose we have a pendulum with a gyroscope bob instead of the ordinary bob; suppose it were held away from the vertical, corresponding to one of our doublets before an electric force acts; supposing, now, it is let fall; gravity, instead of pulling it straight down to the vertical, will make it swing round like a gyroscope pendulum one way or the other, according to the direction of the spin of the top in the bob. So that if this gyroscopic property were attached to a doublet, then when there is an attempt to pull it along the lines of electric force it wil come out a little at right angles, and there will be a current either that way or the other way, according to the sign corresponding to the spin of the top of the gyroscope. So that in addition to the movement along the direction of the lines of force, the doublets would tilt up a little bit at right angles to it; there would be a polarisation in the direction of right angles to it, and that polarisation would produce a current in that direction, so that unless the negative and positive ends move with equal and opposite velocities—that is, unless the centre of gravity of the doublet is exactly midway between the negative and positive charge—then these doublets when they are placed in a magnetic field will be acting like gyroscopes, and if it is attempted to pull them by a force in one direction they must tend to squirm off in a direction at right angles to it; and that I think accounts for the Hall-effect in metals."

In a more recent contribution Sir J. J. Thomson (*Phil. Mag.*, xxix., July, 1915; or *Phys. Soc.* paper, June, 1915) refers to the discovery of K. Onnes that at the temperature of liquid helium some metals can exist in a state in which their specific resistance is less than one hundred-thousand millionth part of the resistance at 0° C., and this fact appears to necessitate the abandonment of the ordinary theory of metallic conduction as the experimental facts are not compatible with the explanation of the phenomenon by an abnormal increase, either in the number or the mean free path of the free electrons. The effects observed by Onnes may be accounted for by a theory of metallic conduction previously given by the author in his "Corpuscular Theory of Matter." On this theory the atoms of some substances contain electrical doublets, *i.e.*, pairs of equal and opposite electrical charges a small distance apart.

J. A. Crowther, "Molecular Physics," 1919, discusses the older theory of conductivity clearly.

N. R. Campbell, "Modern Electrical Theory," 1913, pp. 59-60, opens the subject with three assumptions in order to remove some of the difficulties.

O. W. Richardson, "Electron Theory of Matter," 1914 (see particularly pp. 421-425), introduces the doublet theory, and refers to the work of Onnes.—I am, &c.,

F. H. Loring.

Isotopes.—An important communication on the spectra of isotopic lead and thallium was brought before the Royal Society recently by T. R. Merton. Interferometer measurements of the principal line in the spectra of ordinary lead and in lead from pitchblende showed that in the latter case the line was less refrangible by 0·0050 A, while the lead from Ceylon thorite was more refrangible by 0·0022 A. Thallium, which occurs in pitchblende in very small proportions, was examined by alloying it with pure cadmium, and was found to give a line more refrangible than that of ordinary thallium by 0·0055 A.

NOTES.

Royal Institution.—The following are the lecture arrangements at the Royal Institution before Easter, 1920:—Prof. W. H. Bragg, six lectures adapted to a juvenile auditory on "The World of Sound"; Sir John Cadman, two lectures on "(1) Modern Development of the Miners Safety Lamp, (2) Petroleum and the War"; Prof. G. Elliott Smith, three lectures on "The Evolution of Man and the Early History of Civilisation"; Prof. Ernest Wilson, two lectures on "Magnetic Susceptibility"; Prof. Arthur Keith, four lectures on "British Ethnology"—"The Invaders of England"; Dr. R. R. Terry, three lectures on "Byrd and Palestrina," with musical illustrations; Prof. A. E. Conrady, two lectures on "Recent Progress in Photography"; Prof. A. H. Smith, two lectures on "Illustrations of Ancient Greek and Roman Life in the British Museum"; Lieut.-Col. E. Gold, D.S.O., two lectures on "The Upper Air"; Mr. Stephen Graham, two lectures on "(1) The Spirit of America after the War, (2) The Hope for Russia"; Prof. Alfred Noyes, two lectures on "(1) The Anglo-American Bond of Literature, (2) Aspects of Modern Poetry"; Sir F. Watson Dyson, Astronemer Royal, three lectures on "The Astronomical Evidence Bearing on Einstein's Theory of Gravitation"; Prof. Sir J. J. Thomson, six lectures "On Positive Rays." The Friday evening discourses will begin on Friday, January 16, at nine o'clock, when Prof. Sir James Dewar will deliver a discourse "On Low Temperature Studies." Succeeding discourses will probably be given by the Hon. Sir C. Parsons, Mr. S. G. Brown, Prof. W. M. Bayliss, Dr. E. J. Russell, Mr. W. B. Hardy, the Hon. J. W. Fortescue, Prof. J. A. Fleming, Mr. E. McCurdy, Prof. Sir J. J. Thomson, and other gentlemen.

Livingstone College, Leyton.—We have received an advance copy of the Annual Report and statement of accounts of the above institution for the year 1918-1919. The report tells of the recommencement of the College work of giving training in elementary medicine, surgery, and hygiene to missionaries going to spheres of work abroad far from medical aid. This work was interrupted during the war, when the College was transformed into an auxiliary hospital, to which more than 3000 convalescent soldiers were admitted during the forty months it was open. They much appreciated the treatment received and the finding of a home from home in the College.

The Microscope.—The Faraday Society, the Royal Microscopical Society, the Optical Society, and the Photomicrographic Society, in co-operation with the Optical Committee of the British Science Guild, meeting in joint session, will hold a Symposium and General Discussion on "The Microscope: Its Design, Construction, and Applications," on Wednesday, January 14, 1920. The meeting will be held in the rooms of the Royal Society, Burlington House, Piccadilly, W. 1 (by kind permission of the President and Council), and it will extend over two sessions—from 4.30 to 6.30, and from 8 to 10 p.m. During the afternoon preceding the meeting, from 2.30 to 4.30, an Exhibition will be held in the Library of the Royal Society, which will illustrate recent developments in the Science of Microscopy and the latest applications of the Microscope in all branches of industry. The purposes of the discussion are:—(1) To stimulate the study of and research in microscopical science in the United Kingdom by—(*a*) indicating lines of progress in the mechanical and optical design of the instrument; (*b*) showing by means of exhibits, recent improvements in the Microscope and its technique; and (*c*) the varied uses to which the Microscope can be applied as an instrument of research in the sciences, arts, and industries. (2) To encourage the manufacture in this country of the highest class of instrument and of the optical glass required for

that purpose. The meeting will be presided over by Sir Robert Hadfield, Bart., D.Sc., D.Met., F.R.S., President of the Faraday Society, who will deliver an Opening Address, and Mr. J. E. Barnard, President of the Royal Microscopical Society, will then give a General Survey of the subject, and be will be followed by Sir Herbert Jackson, K B E., F.R.S. Prof. F. C. Cheshire, C.B.E., will then speak on the Mechanical Design of Microscopes, and a paper by Prof. A. E. Conrady on "Microscopical Optics" will be presented.

MEETINGS FOR THE WEEK

Monday, December 15.

Royal Geographical, 8.30.

Wednesday, December 17.

Royal Society of Arts, 4.30. "The Present Economic Position of Russia, and some Aspects of its Future Development," by Constantine Grunewald.

Society of Glass Technology, 2. (At Institute of Chemistry, 30, Russell Square). "Position of the Glass Industry in America," by J. Connolly, Dr. M. W. Travers, and Dr. W. E. S. Turner.

Thursday, December 18.

Chemical Society, 8. "War Experiences in the Manufacture of Nitric Acid and the Recovery of Nitrous Fumes," by Prof. James Walker.

Royal Society of Arts, 4.30. "Some Problems of Indian Education," by J. P. Hartog.

G. R.

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THE CHEMICAL NEWS

VOL. CXIX., No. 3114.

THE ACTIVATION OF CARBON.*

A NEW VIEWPOINT ON THE GENERAL NATURE OF AMORPHOUS CARBON, RESULTING FROM A STUDY OF DEFENSIVE METHODS AGAINST TOXIC GASES USED IN WARFARE.

By N. K. CHANEY.

Introduction.

THE war has brought into existence, as an article of commerce, a new product known as "activated carbon."

Originated as a means of defence against toxic gases in warfare, this material is rapidly finding industrial applications, the extent and novelty of which are not as yet generally appreciated.

The development of activated carbon represents something more than a mere improvement in older forms of adsorptive carbon, or in older processes. It stands for a new viewpoint as to the general nature of so-called amorphous carbon.

Carbon has been hitherto defined as existing in three distinct modifications, diamond, graphite, and amorphous. The latter term has comprised a heterogeneous assortment of natural and artificial carbon materials, possessing a variety of widely different physical and electrical properties, such as manifestly could not be explained by a single allotropic modification of elementary carbon.

Thus, while the complexity of so-called amorphous carbon has long been recognised, we are beginning for the first time to obtain a rational idea of its individual components and their relations to one another.

Some of these ideas and relationships have been indicated in a general way in a recent joint paper by A. B. Lamb and the writer (*Journ. Ind. and Eng. Chem.*, 1919, xi., 420-467).

In other accounts of the work of the Bureau of Mines (*Bull.*, 178-A—War Gas Investigations, Bureau of Mines) and of the Chemical Warfare Service (*Journ. Ind. and Eng. Chem.*, 1919, xi, January and April number) are related the circumstances which led the National Carbon Co. to devote its Research Laboratory to the development of a satisfactory adsorbent charcoal for the American Army.

In accepting this problem, contrary to the popular impression, we possessed no special knowledge of vegetable charcoals, or special acquaintance with the processes and literature regarding the preparation of adsorbent and clarifying materials.

We assumed at the start that whatever general knowledge existed in these fields was inadequate to a solution of the problem, otherwise the stress of two years' gas warfare would have brought about solutions of which the Government would have had adequate information. We were strangely ill-informed of the partial success already obtained by England, France, and Germany.

Thus the belief that no adequate protection existed against certain toxic gases, and our lack of information regarding the methods and results obtained by others in the field, provided the compelling stimulus for a new and fundamental investigation of the first principles of adsorptive activity in carbon.

The result of this intensive research was the gradual development of a broad general conception as to the nature of active carbon and its relations to the generally occurring forms of carbon.

* A Paper presented at the thirty-sixth meeting of the American Electro-Chemical Society, Chicago, September 23-26, 1919.

Alpha and Beta Carbon.

This general theory in its complete form rests upon two independent experimentally established postulates.

1. That elementary carbon (other than diamond and graphite) exists in two modifications, "active" and "inactive," or *alpha* and *beta*.

2. That all "primary" amorphous carbon consists essentially of a stabilised complex of hydrocarbons, adsorbed on a base of "active" or *alpha* carbon.

We will discuss these primary postulates in order.

The active modification of carbon is characterised by a high specific adsorptive capacity for gases, &c. The inactive modification carbon exhibits no special adsorptive capacity whatever.

In addition to this distinction in specific adsorbing power, active and inactive carbon differ in two other important particulars, *i.e.*,

1. Temperature of formation.
2. Chemical activity, or susceptibility to oxidation.

The active modification is formed whenever carbon is deposited at relatively low temperatures by chemical or thermal decomposition of carbon-bearing materials; in general below 500 to 600° C.

The inactive modification results from similar decomposition at higher temperatures, in general above 600 to 700° C.

The active form is rapidly attacked by oxidising agents. Dr. Hulett has shown that slow oxidation occurs at room temperatures. The inactive form is relatively stable towards oxidising agents, resembling graphite in this particular.

It would be premature to assert that these two forms of carbon are true allotropic modifications. It is not yet established that both forms are amorphous. Attempts to find a transition temperature, or to convert *alpha* into *beta* carbon, have been tried without definite success at temperatures up to 1600° C.

This much is established. The two forms are characteristically distinct and easily differentiated, both by their properties and conditions of formation.

Hydrocarbons, such as methane, ethylene, benzene, &c., the decomposition points of which are normally above 700° C., in general give only inactive carbon. Hydrocarbons, such as acetylene, which may be cracked at temperatures as low as 300° C., may give active carbon at lower temperatures and inactive carbon at higher temperatures. The temperature at which molecular carbon is set free is apparently the controlling factor in determining whether it is of the active or inactive variety.

The second part of the general theory relates as stated above to the definition of primary carbon as a stable adsorption complex of active carbon and residual hydrocarbons.

Formation of Active Carbon.

In the ordinary process of distillation of carbonaceous materials, at relatively low temperatures, active carbon is first formed by the thermal decomposition of unstable hydrocarbons. By virtue of its specific adsorptive properties this active carbon adsorbs a further quantity of hydrocarbons, and these hydrocarbons are thereby stabilised to a remarkable extent, so that they are retained under conditions of temperature, pressure, &c., at which they would otherwise be quickly eliminated as such, or suffer decomposition.

For example, quantities of a hydrocarbon resembling anthracene, the boiling-point of which is 360° C., have been isolated from cedar charcoal which had been previously calcined to 850° C. In the same manner chlorine substitution products of hydrocarbons may be obtained in quantity by passing chlorine gas at high temperatures over cocoanut or other charcoals which have been calcined to similar temperatures. This illustrates the power of active carbon to stabilise its adsorbed materials.

This stabilised complex of hydrocarbons adsorbed on a base of active carbon is the product which we have defined

as primary carbon, because it is the original product first occurring in low temperature distillation of carboniferous materials. Many commercial grades of animal and vegetable charcoal are of this character; as are also such cokes as result from the low temperature distillation of bituminous coals, mineral bitumens, &c.

Anthracite coals may be regarded as native primary carbons, since they have been shown to possess an active carbon base saturated with adsorbed hydrocarbons.

Bituminous coals may be similarly regarded, although their hydrocarbon content is in great excess of the adsorptive capacity of the active carbon base. Such excess may be readily removed by distillation under proper conditions.

Ordinary coke, on the other hand, is heavily charged with inactive carbon resulting from the gas treatment to which it has been subjected, *i.e.*, the decomposition in it of volatile hydrocarbons at high temperatures.

Sudden heating of primary carbons to very high temperatures results in the decomposition of the adsorption complex, and the sudden liberation of its hydrocarbons at temperatures much above their normal decomposition point. The latter then break down, forming inactive carbon deposits upon the active carbon. In this way a primary carbon may become self gas treated.

Thus the carbon products resulting from the gas treating of primary carbon at high temperatures by volatile hydrocarbons, either self contained or introduced from without, may be properly termed secondary carbon, which thus possesses a variable composition of active carbon, hydrocarbons, and inactive carbon, depending upon the extent and conditions of the gas treatment.

Primary carbon is therefore essentially an adsorption complex of hydrocarbons adsorbed by a base of active carbon, with or without associated non-adsorbed hydrocarbons.

Secondary carbon is primary carbon partially or completely broken up with the formation or introduction of inactive carbon, by the high temperature decomposition of its hydrocarbons.

From the above description it is self evident that primary carbons as such will not possess a high specific adsorptive power, the active carbon being saturated by the hydrocarbons adsorbed by it. The process of activation must therefore consist fundamentally in the separation and removal of the hydrocarbons from the active carbon.

Experimental Evidence.

The correctness of the general principles just outlined has been substantiated in a very interesting manner. According to theory carbon deposited at low temperatures and absolutely free from hydrocarbons should be the purest form of active carbon and require no activating process. Therefore, carbon was prepared from the reaction $2CO = C + CO_2$, at 300° C., using ferric oxide as a catalyst.

The carbon so formed upon removal of the iron proved to have a specific adsorptive capacity appreciably greater than the best samples of active carbon prepared from hydrocarbon sources.

The practical elimination of the hydrocarbons from primary carbon is, however, extremely difficult.

Because of the stability of the adsorption complex, the temperatures required to accomplish this thermally are so high that secondary formation of inactive carbon by self gas treating is inevitable. Prolonged heating for days under carefully controlled conditions will partially accomplish the desired object, yielding an impaired and gas treated product, which contains a small amount of active carbon. To secure even partial success with this method requires specially selected and prepared forms of primary carbon, in which the character of the hydrocarbon content is such that either the stability of the adsorption complex is lessened or the tendency to gas treating is a minimum.

Having independently discovered the essential principles of this method, it was abandoned because of its practical limitations. It was later found that the British and French had developed this method to the commercial stage.

Second Method of Activation.

The second general method of activation suggested by the theory is to attack the primary carbon by some form of selective chemical action.

The most successful of these is differential oxidation. It has been shown that the adsorption complex could be broken down and the hydrocarbons oxidised or partially decomposed and distilled away from the active carbon.

While many forms of oxidation, both wet and dry, gave some degree of separation, and consequent activation, the yield and quality of activated carbon obtained varied greatly with the kind of oxidiser employed and the manner of its control.

Since inactive carbon is highly resistant to oxidation it is essential to the proper practice of activation by controlled oxidation, that the formation of inactive carbon be avoided at every stage of the operation, including the production of the primary carbon itself. At the same time considerable latitude is permissible for the reason that the tendency to gas treatment varies with the chemical nature of the adsorbed hydrocarbons, *i.e.*, with their decomposition points.

Hydrocarbons present in bituminous coals are found to deposit inactive carbon more readily than hydrocarbons derived from certain other carbon complexes, such as may be prepared from certain woods and nuts. Hence it is that the adsorptive carbon of commerce was hitherto produced only from the latter sources, and not by reason of any inherent impossibility of preparing active carbon from coals, petroleum, and other mineral deposits.

The commercial developments of the oxidation principle as worked out by us and adopted by the Chemical Warfare Service, consisted in the air process, the steam process, and later the use of CO_2.

The discovery of the availability of anthracite and natural coals, and the possibility of manufacturing synthetic primary carbon from pulverised materials by the use of the usual binders employed in carbon manufacture, saved us from a critical shortage of nut materials in the later months of the war.

The special forms arising from these developments were known by the Gas Defence as Dorsite made from cocoanut, Bachite made from anthracite, and carbonite, a synthetic product made by carbon manufacturing processes, from lampblack, powdered coal, or other suitable materials.

The underlying principles of the theory as to the nature of primary carbon are strongly confirmed by the fact that two entirely different methods of activation suggested by it, *i.e.*, controlled distillation and differential oxidation, are in some degree effective.

A modification of the second method is also suggested by the theory, which would consist in the addition of chemical reagents to act catalytically or directly during the primary carbonisation to break down the stabilised hydrocarbons at temperatures below the critical range in which inactive carbon is formed.

This method was successfully employed by us to duplicate German war-charcoal, thus indicating the method by which the latter was formed, which consisted in impregnating wood with various metal salts before carbonisation, and later extracting with acid. This was afterwards verified by the Army Commission visiting Germany.

The amount of active carbon formed by this method is very small in comparison with the better methods of selective-oxidation. On the other hand, the extraction of the dispersed inorganic material leaves a very fine and effective capillary structure capable of adsorbing large quantities of gas at high concentrations of the latter. In this connection it is necessary to explain that we have clearly shown the possibility of differentiating between two

types of adsorptive capacity, one due entirely to the arrangement and physical structures of the adsorbent, which we term the capillary capacity, and a second type characteristic of the material of which the adsorbent is constituted. Capillary capacity is distinguished by large capacity at high gas concentrations and by rapid equilibrium between adsorbent and gas phase, in either direction, the gas being removed as readily as it is adsorbed. Specific capacity is characterised by very considerable capacity at low gas concentrations, and by extremely low rate of loss during reversal of the adsorption process.

Thus by saturating an adsorbent and then noting the rate at which different portions of the adsorbed gas are removed, it has been found possible to evaluate the specific and capillary components of the total adsorptive capacity.

The weight of gas retained, after rapid weight loss has ceased, called the "retentivity" of the adsorbent, is a measure, therefore, of the proportion of active carbon present in a given weight of adsorbent. This test applied to pre-war charcoals shows that their adsorptive capacity is almost wholly capillary and dependent upon the physical structure left by distillation in the primary carbon. In general even this capacity is extremely small compared with present standards.

German charcoal is distinguished by the very high ratio of capillary to specific capacity. On the standard accelerated tube tests employed by the Chemical Warfare Service, German charcoal thus showed up very well because of the high concentrations of gas employed. If one were to breathe through the coal at the end of such a test, however, one would soon inhale 75 per cent or so of the gas previously adsorbed. Thus German charcoal received for a time a wholly unwarranted reputation.

Development of the Theory.

We have now outlined a general theory of the nature of amorphous carbon and the principles underlying the successful isolation of active carbon.

As a working hypothesis the conceptions above outlined have proved their worth by enabling us to develop methods for the commercial manufacture of adsorbent and catalytic carbon, of a character unapproached in pre-war charcoals and from a variety of raw materials hitherto considered useless for such purposes.

Upon the chemical side we have provided a new means of attack upon the problems of the structure and constitution of the various forms of amorphous carbon.

The actual development of the two principal conceptions underlying the complete theory was the reverse of the order of exposition. At the outset of the work the fundamental question was why and how adsorbent charcoals differed from other charcoals less adsorbent.

Because of the vital urgency of the problem at that time and the need of haste, we know that it would be fatal to back a wrong hypothesis. So far as we could learn the following hypotheses were current:—

1. That a special form of hydrocarbon film was left under certain conditions of distillation which was especially active.

In the case of such gases as chlorine which may form substitution products, such a possibility certainly exists even in the light of present developments.

2. That adsorption depended upon the physical structure of the adsorbent, *i.e.*, the diameter of the capillary pores.

As we have seen this actually represents the type of adsorption previously common in adsorbent materials, other than active carbon, but is not the type of specific adsorption desired for effective field protection against low concentrations of toxic gases.

3. That adsorptive power depended upon the quantity of fixed gases as carbon monoxide, oxygen, &c.

The difficulty with the latter view was that, if true, it suggested no line of attack.

After considering the above we adopted the hypothesis that absolutely pure amorphous carbon would be active, and that the most obvious impurities in charcoals formed by destructive distillation were hydrocarbons.

It was by no means readily accepted by many chemists that ordinary low boiling hydrocarbons could exist as such in chars which had been heated up to nearly 1000° C. for hours.

The crucial experiment was therefore the proof that ordinary hydrocarbons resembling anthracene for example could be removed as such from a charcoal previously calcined to 850° C. by simply distilling it in the presence of air at 300° C.

This not only proved the existence of the hydrocarbons, but indicated directly that by oxidation they could be broken down from the adsorption complex. No explanation was forthcoming, however, as to why certain forms of carbon could be activated while others could not.

It was not until work was commenced on coals and artificial carbons that the significance of the decomposition temperature of the carbon was discovered.

This clue cleared up the entire field and provided the explanation for many previous anomalies, as why, for example, artificial carbons taken from the same furnace could, some of them, be activated and others not. Our observation that all forms of retort cokes were wholly inactive and incapable of activation was also explained. The fundamental conditions surrounding the formation of primary carbon, if the latter was to be capable of activation, were thus completely defined.

To sum up, active carbon is essentially a special form of pure amorphous carbon, deposited at low temperatures and free (1) from adsorbed stabilised hydrocarbons which are normally associated with it and which lessen its power of combining with other substances; (2) from inactive carbon formed by gas treating, *i.e.*, by the decomposition of hydrocarbons upon its surface at high temperatures.

It is possible for the first time to prepare intelligently such active carbon on a large scale from whatever sources of carbon-bearing material may be cheapest, or most desirable for the particular purposes in view.

The unique properties of this material both as catalyst and adsorbent suggest that it will find many industrial applications.—*Canadian Chemical Journal*, iii., No. 11.

THE ATOMIC NUMBERS.

By HAWKSWORTH COLLINS.

The following extracts are taken from a lecture delivered by Prof. Soddy before the Chemical Society on December 19, 1918:—

"The figures at the head of each place represent the atomic numbers or number of the place in the Periodic Table, starting with H as unity, He as 2, Li as 3, and so on. Moseley found that the square root of the frequency of the characteristic X-radiation of an element was, for the K series of radiations, proportional to integers less by one than the atomic numbers. Strictly speaking, there is no means of determining the absolute value of the at. number, but the starting point having been fixed for any one element, the others can then be found in terms of it. Moseley assumed the at. number of Al as 13, as it is the thirteenth known element in the list starting with H as unity. It is unlikely that any new element will be discovered between H and Al, although if they were it would be necessary to alter the whole of the subsequent at. numbers to correspond. . . .

"The actual numbers in the figure, 92 for uranium, for example, are derived from the assumption that the at. number of Al is 13, but it is well to remember that, although relatively to one another based on experi-

mental evidence, the absolute value is to some extent arbitrary. . . .

"The nuclear atom is a miniature solar system, like most model atoms, the negative electrons occupying the atomic volume by their orbits around a relatively excessively minute central sun or nucleus, wherein the atomic mass is concentrated, and consisting of an integral number of atomic positive charges equal to the at. number of the element, and the number of electrons in the outer shell. . . .

"The at. number of the element is its net nuclear charge, the difference between the positive and negative charges entering into its constitution. . . .

"The actual number is now known to be rather less, as an average, than half the numerical value of the atomic weight."

The above extracts show that the meaning of the expression, "atomic number," is not quite clear. It is employed—

(1) To denote the position of each element in ascending order of atomic weight, modified where necessary by the Periodic Table;

(2) To denote the number of positive charges in each element;

(3) To denote the net nuclear charge or algebraic sum, *i.e.*, the difference of the positive and negative charges.

It seems clear that Prof. Soddy expects that it will in the future be found experimentally (when all the elements have been discovered) that the 30th element, *e.g.*, in the order of at. wt., will possess 30 positive charges of electricity.

Prof. Soddy's statement that "if a new element between H and Al were discovered, it would be necessary to alter the whole of the subsequent atomic numbers to correspond" is difficult to understand, because if it has been found experimentally, *e.g.*, that Al has 13 positive charges, it could not be correct to say that its atomic number is 14.

Table I. gives three columns of experimental data together with three columns of remarks.

TABLE I.

	Nearest whole number to at. wt.	Remark.	Max. val.	Remark.	Proposed atomic number.	Remark.
H ..	1	odd	1	odd	1	odd
He ..	4	even	2	even	2	even
Li ..	7	odd	1	odd	3	odd
Gl ..	9	odd	3	odd	4	even
B ..	11	odd	3	odd	5	odd
C ..	12	even	4	even	6	even
N ..	14	even	5	odd	7	odd
O ..	16	even	2	even	8	even
F ..	19	odd	1	odd	9	odd
Ne ..	20	even	0	even	10	even
Na ..	23	odd	1	odd	11	odd
Mg ..	24	even	2	even	12	even
Al ..	27	odd	3	odd	13	odd
Si ..	28	even	4	even	14	even
P ..	31	odd	5	odd	15	odd
S ..	32	even	6	even	16	even
Cl ..	35	odd	7	odd	17	odd
A ..	40	even	0	even	18	even
K ..	39	odd	1	odd	19	odd
Ca ..	40	even	2	even	20	even
Sc ..	44	even	4	even	21	odd
Ti ..	48	even	6	even	22	even
V ..	51	odd	5	odd	23	odd
Cr ..	52	even	6	even	24	even
Mn ..	55	odd	7	odd	25	odd
Fe ..	56	even	4	even	26	even
Co ..	59	odd	3	odd	27	odd
Ni ..	59	odd	3	odd	28	even

The above shows a regularity to which there are four exceptions, viz., Gl, N, Sc, and Co (or Ni).

The Odd and Even Rule, as published in the CHEMICAL NEWS, Oct. 11, 1907, and Nov. 14, 1913, can now be extended as follows:—

When the at. wt. of an element is an even number its maximum valency and atomic number are also even numbers, and when the at. wt. is an odd number its maximum valency and atomic number are also odd numbers.

It will be noticed that from Sc onwards the proposed atomic numbers begin to deviate from the experimental generalisation that the atomic number is rather less as an average than half the numerical value of the at. wt., and this deviation goes on increasing in size until we arrive at 92 for uranium, which is very much less than half its at. wt.

We will now find whether there is sufficient reason for an assertion that a truth is contained herein notwithstanding the four exceptions.

The probability that when the atomic number of H is odd its atomic weight and maximum valency would also both be represented accidentally by odd numbers is 1 : 4.

The probability that when the atomic number of He is even its atomic weight and maximum valency would also both be even numbers by accident is 1 : 4.

Therefore the probability that the same thing would happen accidentally in the first 28 elements is $1 : 4^{28}$; with four exceptions—

$$1 : 4^{28 - \frac{4\times4}{3}} = 1 : 35 \text{ billion.}$$

The easiest way to see that this is correct is to notice that with 21 exceptions the probability becomes—

$$1 : 4^{28 - \frac{21\times4}{3}} = 1 : 1;$$

i.e., the odds are even that only 7 out of 28, or one out of every four elements, would be likely to have either three odds or three evens accidentally, and this is evidently correct.

Therefore the probability that the state of affairs in Table I. has not happened by accident is 35 billion to 1.

Therefore the probability that this matter contains a truth is 35 billion to 1; *i.e.*, it is absolutely certain that it contains a truth.

In considering the structure of the chemical element we are looking for any peculiarities that may be common to several elements, without expecting that all of them are built up in exactly the same manner. If the elements had been constructed in one absolutely regular way their structures would have been obtained years ago. When scientists say that they object to exceptions it is equivalent to their saying that they know that all elements have been built up on the same lines.

We will now proceed to find what the truth is that underlies the first and third columns.

It was shown in the CHEMICAL NEWS, Feb. 28, 1913, that the first main principle in the constitution and structure of atoms is as follows:—The non-metallic nature of an element is always due to a pair or pairs of electro-positive forces, each pair emanating from a portion of the element of which the mass is four, taking the mass of an atom of hydrogen as unity.

And it was also shown (CHEMICAL NEWS, Oct. 11, 1907, and Jan. 16, 1914) that this mass of 4 splits up into 1 and 3, from each of which emanates one electro-positive force.

This contains the key to the solution of the problem with regard to the atomic weights and atomic numbers as follows:—

If the nearest whole number of the atomic weight of an element be split up into 3's and 1's alternately, always commencing with a 3, the number of portions thus obtained represents the atomic number of the element, *i.e.*, the number of positive charges in the element.

Table II.

	At. wt.			Number of parts into which at. wt. is divided.	Experimental atomic number.
H ..	1	=	1	1	1
H_3 ..	3	=	3	1	1
He ..	4	=	3+1	2	2
Li ..	7	=	3+1+3	3	3
B ..	11	=	3+1+3+1+3	5	5
C ..	12	=	3(3+1)	6	6
O ..	16	=	4(3+1)	8	8
F ..	19	=	4(3+1)+3	9	9
Ne ..	20	=	5 "	10	10
Na ..	23	=	5 " +3	11	11
Mg ..	24	=	6 "	12	12
Al ..	27	=	6 " +3	13	13
Si ..	28	=	7 "	14	14
P ..	31	=	7 " +3	15	15
S ..	32	=	8 "	16	16
Cl_1 ..	35	=	8 " +3	17	17
Cl_2 ..	36	=	9 "	18	18
K ..	39	=	9 " +3	19	19
A, Ca	40	=	10 "	20	20
Sc ..	44	=	11 "	22	22
Ti ..	48	=	12 "	24	24
V ..	51	=	12 " +3	25	25
Cr ..	52	=	13 "	26	26
Mn ..	55	=	13 " +3	27	27
Fe ..	56	=	14 "	28	28
Co, Ni	59	=	14 " +3	29	29

The probability than the at. wts. of the first 28 elements would accidentally be odd or even according as their atomic numbers are odd or even with four exceptions is one to a million. But this is the simplest kind of coincidence, and has no reference at all to any particular odd (or even) number representing the at. wt. when the atomic number is odd (or even); so that when it is found that, if the atomic number is odd, the atomic weight is represented by a particular odd number, and if the atomic number is even, the atomic weight is represented by a particular even number, in 24 cases out of 28, it is evident that the probability is infinitely great against this state of affairs happening by accident. Therefore it is absolutely certain that a truth is contained in it.

It is plain, then, that the truth sought for is as follows:—

The great majority of the atomic weights of the elements can be split up in a regular manner into masses of 3 and 1 from each of which emanates one electro-positive force.

It is evident from Table II.:—

1. That the atomic number is not determined by its position in the order of ascending at. wt.

2. That instead of stating that the atomic number is "on the average rather less than half the numerical value of the at. wt.," the exact truth may be stated as follows:—When the at. wt. is an even number the at. number is half the at. wt., and when the at. wt. is an odd number the at. number can be obtained by subtracting 1 from the at. wt. and halving the result.

3. That there are now only two exceptions, Gl and N.

4. That the difference between the at. wt. and at. number of any element is an even number; also the difference between the at. wt. and max. val. is even, and therefore the difference between the at. number and max. val. is also even.

5. That the reason of the Odd and Even Rule as far as atomic numbers and weights are concerned is:—When an even number of 1's and 3's are added together the result is even, and when an odd number of 1's and 3's are added together the result is odd.

6. That another proof is afforded that the at. wts. are integers when O = 16; for 26 out of 28 of those elements whose at. wts. have been shown to be more exactly determined than others, are built up in a regular manner of masses of 3 and 1, and in each of 7 of the 28 cases the sum of these masses has been found experimentally to be an integer, therefore the at. wts. of all the 26 must be integers.

The probable structure of Cl_1 which has prevented chemists from being able to distinguish it from Cl_2, must be left until the structure of this element is considered.

In Table I. the heading "Proposed Atomic Number" means "The Atomic Numbers as Proposed by Moseley."

In Table II. the heading "Experimental Atomic Number" means "the atomic numbers in accordance with the experimental generalisation stated by Prof. Soddy in the following words:—The actual number is now known to be rather less, as an average, than half the numerical value of the atomic weight.

It is a necessary corollary of all that precedes that when three atoms of H unite to form H_3 two of these H-atoms lose their positive charges altogether, and never regain them as long as they form part of an element. But there is no further loss of positive charges however complicated the structure of the element may be.

By reasoning upon all three columns of Table I. together it is possible to determine a simple diagram for each element (with absolute certainty of the truth being contained therein), exhibiting its structure and the connection between atomic weight, maximum valency, electro-positive and negative charges, atomic number, and the forces which unite the parts of atoms, but which are not chemically evident.

THE MAGNETIC PROPERTIES OF SOME RARE EARTH OXIDES AT LOW TEMPERATURES.

By E. H. Williams.

In a previous article (*Phys. Rev.*, 1918, N.S., xii., 158) the author gave the results obtained in the study of the magnetic properties of some rare earth oxides at temperatures above that at ordinary room temperature. Since making the above investigation the apparatus has been reconstructed to adapt it to low temperature measurements, and the magnetic properties of the same oxides have been studied down to temperatures of about −150° C.

The two investigations overlap each other at room temperature measurements, so that it is possible to check one against the other. This is important, inasmuch as the previous values found by the author for the magnetic susceptibility of the various rare earth oxides were lower than those found by other experimenters, among whom was O. A. Randolph, of the Laboratory of Physics, University of Illinois, who measured the magnetic susceptibility of several of the above oxides at temperatures ranging from room temperature to −140° C.

The method used was the same as that employed for higher temperatures. Low temperatures were obtained by the method described by C. T. Knipp (*Phys. Rev.*, 1902, xv., 125). It was possible to make determinations of the susceptibility at temperatures as low as −150° C. Determinations of the magnetic susceptibility were made at three or four temperatures between that and room temperature.

The temperatures were measured by means of a copper-advance thermo-couple of No. 40 wire, which was calibrated both before and after making the magnetic measurements and was found to have remained perfectly constant. One junction of the thermo-couple was kept in melting ice and the other was embedded in the oxide whose temperature was to be determined. It was necessary to correct for conduction of heat along the wires leading to the junction in the oxide, since the temperature gradient near this junction was quite large. At −150° C. the correction was 5·7° ± 0·3°. This was the largest source of error in the temperature determinations.

After reconstructing the apparatus to adapt it to low temperature measurements it was necessary to redetermine all constants, so that, experimentally, the values

obtained at low temperatures were entirely independent of those obtained at high temperatures.

Measurements were made of the magnetic susceptibility of the oxides of seven of the rare earths, namely, dysprosium, erbium, gadolinium, samarium, neodymium, lanthanum, and yttrium. The results for the three oxides having the highest magnetic susceptibility are shown in Tables I., II., and III. The values given in these tables were taken from curves obtained by plotting the observed results. A comparison of the values of the magnetic susceptibility at 20° C. given in these tables with the values found at the same temperature in the previous work shows that, in all cases, the agreement is within experimental error.

Table I.—*Dysprosium Oxide.* 99·5 + *per cent Pure.*

t.	T.	$X \times 10^6$.	$XT \times 10^3$.	$X(T+15) \times 10^3$.
20	293	233·3	68·4	71·9
0	273	250·0	68·2	72·0
−40	233	291·3	67·9	72·2
−80	193	347·4	67·0	72·3
−100	173	384 2	66·5	72·2
−120	153	430·2	65·8	72·3
−140	133	490·0	65·2	72·5

Table II.—*Erbium Oxide.* 99·6 + *per cent Pure.*

t.	T.	$X \times 10^6$.	$XT \times 10^3$.	$X(T+13·5) \times 10^3$.
20	293	188 6	55·3	57·8
0	273	201·7	55·1	57·8
−40	233	234·8	54·7	57·9
−80	193	282·3	54·5	58·3
−100	173	314 8	54·5	58·7
−120	153	355 0	54 3	59·1
−140	133	402·8	53·6	59 0

Table III.—*Gadolinium Oxide.* 99 + *per cent Pure.*

T.	T.	$X \times 10^6$.	$XT \times 10^3$.	$X(T+12) \times 10^3$.
20	293	129·7	38·0	39·6
0	273	138·2	37·7	39·3
−40	233	160·7	37·4	39·4
−80	193	194 2	37·5	39 8
−100	173	217·0	37·5	40·1
−120	153	244·6	37·4	40·4
−140	133	279·0	37·1	40·5

According to Curie's law of susceptibility of paramagnetic bodies times the absolute temperature is equal to a constant. Few substances, however, follow this law exactly, but follow a modification of the law—namely, the susceptibility times the absolute temperature plus a constant is equal to a constant—that is, $X(T+\theta)$ = constant, in which each substance has its own value of θ.

The value of θ for dysprosium oxide found by the author in the work referred to above was 15. This gave for an average value of the constant $X(T+\theta) \times 10^3$, for a temperature range from 300° C. to 20° C., 72·1. In the present work with dysprosium oxide, Table I., the same value of θ has been used, with the result that the constant increases with decrease of temperature. The same is true in the cases of erbium oxide and gadolinium oxide, Tables II. and III., where the value of θ previously found for these oxides is again used. Neodymium oxide showed the same result. Taking the value of θ equal to 44, as previously found, the value of $X(T+\theta)$ increases by about 4 per cent in the temperature range from 20° C. to −140° C.

In Table IV. is given a comparison of the values of the magnetic susceptibility at 20° C. reported on p. 161 of the article referred to above with those corresponding to the same temperature in the present work.

In the earlier article the conclusion was drawn that the magnetic susceptibility of samarium oxide does not vary with the temperature. In the present investigation the results show clearly a slight increase in the magnetic susceptibility with decrease in temperature, the value of X being about 10 per cent greater at −140° C. than at room temperature. However, this is a relatively small increase, as the susceptibility of the oxides shown in Tables I., II., and III. more than doubles in value in the same temperature range.

Table IV.—*Temperature,* 20° *C.*

	$X \times 10^6$.	$X(T+\theta) \times 10^3$.
Dy_2O_3 —		
Table I., new	233·3	71·9
Table V., old	234·1	72·1
Er_2O_3—		
Table II., new	188 6	57·8
Table IV., old	189·1	58·0
Gd_2O_3—		
Table III., new	129·7	39·6
Table IV., old	130·1	39·7

Lanthanum oxide again gave negative values for the magnetic susceptibility. However, the values were so small that it was impossible to determine whether there was a variation or not. Any slight variation which may exist would be masked by the errors due to experiment. In the case of yttrium oxide the magnetic susceptibility was found to increase slightly with decrease of temperature, but since the magnitude of the susceptibility is less than 1×10^{-6}, the experimental error is relatively large.

The results shown above lead to the conclusion that θ is not a constant, but is some function of the temperature—a function such that the value of θ decreases with decrease of temperature. If this is true Curie's law is followed more closely, in the case of rare earth oxides, at low temperatures than at high temperatures. It is interesting to note that H. K. Onnes and A. Perrier (*Konink. Akad. Wetensch,* Amsterdam Proc.; xvi., 894, March 26, 1914) found that, in the case of oxygen, the deviation from Curie's law becomes greater with decrease of temperature.—*Physical Review,* 1919, xiv., No. 4.

HELIUM.

A New Canadian Commercial Asset.

That Canada will soon produce helium in commercial quantities is the confident opinion of some of the best known of Canadian scientists. As a non-inflammable substitute for hydrogen gas used in dirigible balloons it has been found most valuable, and as a commercial product its value is enhanced by its comparative scarcity, Canada and the United States being, as yet, the only countries in which it has been found. In Canada it is derived from the natural gas fields of Southern Alberta.

Prof. J. C. McLennan, Professor of Physics in the University of Toronto, who during the war acted as adviser to the British Admiralty, brought the attention of that body to the fact that it could be used as a substitute for hydrogen gas. Under the direction of the Admiralty a series of extensive investigations and experiments were conducted under the supervision of Mr. Eugene Coste, President of the Canadian Western Natural Gas, Light, Heat, and Power Co. at the Calgary plant of this corporation.

The Canadian natural gas in which helium exists was found to have an advantage, as it proved to be much more readily broken up into its constituent parts, the helium being extracted by first liquefying the methane, which is one of the constituents, then liquefying the nitrogen, which left the helium free.

Experiments are now being conducted at the University of Toronto to discover if there are other uses to which helium can be put than solely as a buoyancy producer for lighter-than-air craft.

In discussing the subject of helium before a Parliamentary Committee Prof. J. C. McLennan recently said:

—"In 1903 it was observed that many of the natural gases of Canada contained a small percentage of helium. In the spring of 1916 it was found that the largest supply of natural gas in Canada, namely, that located at Bow Island, Alberta, contained a little over 0·36 per cent of helium. This is comparatively small, and apparently an insignificant amount, and yet I may tell you that this wonderful gas was so rare and so costly that at pre-war prices the value of the supply of it which escaped into the air from the furnaces and stoves of Calgary and other houses on the pipe line was 50,000,000 dols. per day. By the developments which have taken place during the past two years the cost of producing the gas in a pure state has been reduced, roughly, 100,000 times. Owing to the advance it became possible to utilise this gas in place of hydrogen in lighter-than-air aircraft. With the buildings and plants projected by the Admiralty and the authorities of the United States, we should, had the war continued, been able by June of this year to produce about 2,000,000 cubic feet of this gas per month for use in our balloons at the front. This would have meant the creation of a great industry in Canada.

"Although it will not pay to use the gas for balloons under peace activities every effort is being made to develop technical uses for this gas, and it is possible that it may yet be required in large quantities for the production of gas-filled lamps and other articles of commerce."

Further investigating and experimenting have led to the confident prediction that helium will soon be included among the valuable commercial products of the Dominion. Incidentally, this is a tribute to the work of scientific and industrial investigation now being conducted in Canada.

THE POSITION OF THE CHEMIST IN SOUTH AFRICA.*

By JAS. GRAY, F.I.C.

It is my privilege as President, at this the first meeting of the Society for the session, to deliver what is termed an inaugural address. This privilege is also usually said to be a pleasure; but if the truth be told I am sure that, speaking for those who have been in a similar position, we should say it is really a most trying ordeal.

I will commence by admitting frankly that I have studied the addresses which have been delivered by previous occupants of the Presidential Chair with a view to obtaining ideas as to a suitable subject for my address. (I think this is quite customary though not often confessed). As a result of my investigations, I found that in some cases recent advances in the branch of science which the President professed had been enlarged on; in others a general survey of the subjects included in the Society's title had been made; and in a few instances the work of the previous year was discussed, with suggestions for the future.

As I consider that fewer pitfalls await those who speak on the subject with which they are familiar, I have decided to discuss, as briefly as possible, the position of the chemist in South Africa. I think I may claim to have a knowledge of this subject, due to my intimate association during the past seven years with your sister Society—the South African Association of Analytical Chemists.

The importance of chemistry in relation to everyday economics was brought into prominence by the war; and in the new era which is forecasted, we expect it to be generally realised that the encouragement of chemistry is essential for the well-being of the State.

Shortly after the outbreak of the war, I read in an American chemical journal an article dealing with the recent recognition of the chemical profession by the public, especially in its relation to the coal-tar industry. In it occurred the following paragraph, which to my mind was particularly apt:—

> "The public acknowledgment of our responsible connection with this important industry is a great accomplishment for our profession when we recall that only six months ago the chemist was known chiefly by the drug store he kept."

Undoubtedly an erroneous impression exists in the mind of the public on the relation between the "chemist" and the "pharmacist," and it is desirable that steps should be taken to alter this.

The ignorance of the public and also of the Government in connection with the work of the chemist is to a large extent due to the nature of his pursuits. In the past, his labours have been carried out in an atmosphere of seclusion, but the war has brought him more into the open, and it is his duty to see that he maintains that position among the other professions which he has justly acquired, and that he becomes recognised as an essential factor in the industrial development of the country. Judging by the steady organisation which is being quietly carried on all over the world by members of the profession, it appears that chemistry is not to be allowed to sink back into that obscurity which had hitherto hampered it.

Chemists as a class are apathetic, and many are content to stand aside and criticise the efforts of those who, having the interests of the profession at heart, are endeavouring to raise its status. The attitude of these critics is to stand aloof until they see material gain at hand, not realising that as the position of their fellows improves so must theirs also improve. Such an attitude is extremely selfish, and unworthy of the profession.

An examination of the opportunities afforded to chemists in this country shows that the appointments available can be divided into three groups, viz., Government, Industries, and Miscellaneous. I propose to examine these briefly.

The Government employs a considerable number of the members of the profession. According to the Civil Service List for 1918, no less than twenty-eight chemists were in its employ, being divided into two departments, viz., the Department of the Interior and the Department of Agriculture—the former being in the sub department of Public Health and dealing with the matters concerning this department, and the latter with agriculture and agricultural education. When, however. we examine the pensionable emoluments offered to those in its service we can only come to the conclusion that these are far from being satisfactory.

In the Department of the Interior occasional appointments are made in the grade—laboratory assistants. The qualification required for this post is stated to be "A knowledge of chemistry." What this means admits of different interpretations. The salary is £125, rising, by annual increments of £15, to £200 per annum, which might be sufficient for a bottle-washing apprentice, but is certainly not encouraging to the youth who has had an expensive professional training.

The next grade is termed "Second Grade Chemical Assistant." For this appointment "a graduate of a University with Honours in Chemistry or a Fellow or Associate of the Institute of Chemistry, with knowledge of the analysis of foods and drugs," is eligible, and the salary is the munificent (*sic*) one of £220 per annum, rising, by annual increments of £20, to £360 per annum.

The next grade, "First Grade Chemical Assistant," is usually filled by promotion, as is to be expected. though this is not always the case, as was shown by a recent advertisement. The salary attached to this post is £380, with annual increments of £20, to £440 per annum, and this is the plum of the profession forsooth!

In view of the qualifications and experience demanded, an applicant for an appointment as second grade chemical assistant cannot be under twenty-three years of age, and if his application is successful and he receives the appoint

* Presidential Address delivered before the Chemical, Metallurgical, and Mining Society of South Africa, September, 1919.

ment, then, at the age of thirty, a generous Government pays a tried and trusted servant the stupendous salary of £30 per month.

There he remains praying for the retirement or death of the man above him.

A comparison between the qualifications demanded of these "second grade" men and those of the highly-paid departmental clerks who draft these advertisements would be an odious one.

A summary of the pensionable emoluments in the respective grades is interesting and at the same time instructive:—

Public Health Department Laboratories.

Government analysts, three receiving £460 to £850.
Assistant analysts, two receiving £550.
First grade chemical assistants, five receiving £380 to £450.
Second grade chemical assistants, six receiving £220 to £360.

On turning to the Agricultural Department the position is quite as disheartening. The chemical appointments, which number eleven, may be divided into three classes, as follows:—

(*a*) Veterinary research, one receiving £700 per annum.
Agricultural research chemist, one receiving £650 per annum.
(*b*) Agricultural Laboratory, Pretoria—Assistant chemists, two receiving £380 per annum.
Second grade chemical assistant, one receiving £220 per annum.
(*c*) Schools of Agriculture—Lecturers in chemistry, four receiving £285 to £430 per annum.
Research chemists, two receiving £285 and £320 per annum.

Recently several Government advertisements have appeared in the local press for chemists in the Agricultural Department, for engineers in the Department of Mines and Industries, and for a foreman carpenter in the Department of Lands.

A comparison of the qualifications required from applicants with the salaries attached to the position is not without humour.

Division of Chemistry, Department of Agriculture, Pretoria.

"Candidates should hold a University degree (with honours in chemistry) and possess a knowledge of agricultural and analytical chemistry. The commencing salary is at the rate of £300 per annum, rising, by annual increments of £20, to £400 per annum."

Assistant Chemists at the Schools of Agriculture.

"Candidates should have graduated in science and specialised in chemistry, or possess qualifications regarded as equivalent to such a degree. Officers appointed will be required to assist the lecturer in chemistry in connection with the instruction of students and in experimental and analytical work. The commencing salary is at the rate of £240 per annum, rising, by annual increments of £15, to £300 per annum."

Assistant Inspectors of Machinery, Department of Mines and Industries.

"The commencing salary attached to each post is £400 per annum, rising, subject to satisfactory service, to £500. . . . Candidates must have had a thorough training in theoretical and practical engineering, and possess a good knowledge of electrical engineering."

Foreman Carpenter, Department of Lands.

"Applicants must be capable to take charge of and supervise the erection of buildings. Salary £40 per month."

A local association of chemists some time ago took exception to an advertisement issued by the Department of Defence in which the members of the profession were classified with blacksmiths, carpenters, and other tradesmen. A heated press correspondence took place, carried on chiefly by partisans of the carpenter, in which they stated that there should have been no protest by the chemist. Judging from the salaries offered in the advertisements which I have quoted, the carpenters should not have claimed equality, but superiority. The advertisements also supply the answer to the question—"What shall we do with our boys?"

It will be generally admitted that the Government is not giving a "fair deal" to the chemist. The offer of such emoluments to men who must be so highly trained as the chemist is certainly a reflection on the intelligence of those who offer them. The chemist is certainly entitled to a salary which is at least comparable to that given to the artisan, and the time and money spent in acquiring the necessary training should also be taken into account.

I hold no brief for the unfortunate Civil Service employee, but the time has certainly arrived when such injustices must be remedied, and the remuneration should be proportionate to the value of the chemists' services to the country. This lack of satisfactory recognition of scientific officers is common to all departments of the Civil Service, and it is not surprising to find that men who are of the greatest value to the country are being constantly enticed away by more remunerative offers from other Governments and private employers. This depletion has been the text of many scathing articles in the press, and the "penny wise and pound foolish" attitude of the Government has been condemned in forcible language.

The chemical industries are responsible for the employment of the next larger number of chemists, and unfortunately it cannot be said that the position in this case is particularly satisfactory either. It was the practice in pre-war days for many of these firms to import their chemists on contract. The salaries offered, when examined from the oversea standpoint, seemed alluring, but disillusionment was soon experienced on arrival in this country. Unfortunately, the alternative opportunities are so limited that the unlucky chemist was compelled to accept the unfair conditions. Under any circumstances, there are so many chemists being trained here nowadays that there should be no necessity for overseas importations.

Recently an industrial firm endeavoured to obtain the services of a chemist from England, and the inducement put forward was a salary of £200 per annum. It is gratifying to record a refusal of this generous offer. Another case I know of is in connection with a chemist who was brought out here on contract, his salary being kept at a low figure until a suitable opportunity came his way and he gave notice. A good increase was then offered him and he decided to remain; a decision he now regrets. His experience and qualifications are such that he is able to undertake, as well as supervise, practically all the technical operations conducted in this industry, and in the absence of any of the other officials he is called upon to undertake their duties as well as carry on his own work as chemist. Whereas the artisans employed in the factory have the usual forty-eight hours per week, he is compelled to do twelve hours daily and is frequently called upon to do night work. His contract also includes a pernicious clause preventing him from accepting a situation with any similar firm in the Union for three years after leaving his present situation. This, I believe, is illegal, but the firms in this particular branch of the industry are so closely related that he would be compelled to lose all the advantage of his previous experience and take a situation in some other branch of chemistry.

It seems that the vision of the industrial employer is, like the Governments, narrow and confined, and they both fail to appreciate the fact that contentment leads to efficiency. As an instance of the mental outlook of the

employer, I shall quote the case of one factory where well over a dozen chemists are employed, distributed throughout the factory and the laboratory. The laboratory, as is to be expected, controls the raw material and the output, but, nevertheless, those employed in it are graded on what is termed "non-productive work"!

The remaining or miscellaneous chemists are employed in the smaller industries (where the chemist is frequently called upon to act as a handyman), the various Universities and University Colleges, private and other laboratories, and the mines. In most cases the salaries of the assistants are below those paid to artisans.

The question then arises as to the action to be adopted in an endeavour to raise the status and at the same time the emoluments of those who practise the profession of chemistry. To this matter I have given much thought, and I fear it can only be achieved by educating those who are in authority and the public to appreciate and understand the value and importance of the services rendered both directly and indirectly by the chemist. The Government and Government Departments, not only here but in Europe, are notoriously ignorant on scientific matters, and no opportunity should be lost of instructing the legal luminaries who determine our destinies about the many ways in which science is able to assist them.

It will necessarily be a slow undertaking, but I am satisfied that it can be done, and if we, who are at present practising the profession, do not derive much benefit from it, those who follow will have reason to thank us for our perseverance on their behalf.

The profession will always be burdened by one great disadvantage, until such time as Government recognition is obtained, and that is the existence of the type of so-called chemist who acquires his knowledge by being apprenticed as a youth in a works or other laboratory where he obtains his practical knowledge; the theoretical portion, such as it is, being nominally acquired by attendance at evening classes. This system is entirely unsatisfactory, and ultimately places on the market—in competition with fully qualified chemists—a man who is only partially trained, and who, sometimes unfortunately, owing to his lack of knowledge, tends to bring discredit on the profession. I say most emphatically that in this country at any rate, it is not yet possible to acquire an adequate knowledge of the profession by this means, and the fond father whose son has achieved distinction in chemistry at school must be instructed in the proper manner in which a satisfactory knowledge of the profession of chemistry can be gained—without expecting his son to earn money too early. I admit that there are those who have been able to rise superior to their environment—and the more honour to them—but they are the exception. The qualifications for a Government appointment nowadays, and rightly so, are such that only those who are fortunate enough to graduate at a University can hope to be successful, and the tendency among private employers, especially in connection with the more remunerative posts, is to demand a similar high standard.

The position of research in South Africa is disappointing it will be generally admitted. There are very few chemists in the Union who have the requisite time and adequate facilities for conducting a research of any magnitude.

In the universities, where, taking an analogy with similar European seats of learning, we might expect to find some enthusiasm in this direction, it is disappointing to state that comparatively little research work is done. To those of us who are accustomed to home conditions where professorial appointments are largely made on the candidate's reputation in research, the position, to say the least, seems peculiar. An improvement appears doubtful when we find that in the three years' course now required for the Bachelor of Science degree, no provision is made to instruct the student, even in the most modest fashion, in the methods of research. There does not seem to have been much original work done in connection with our industries, judging by the small number of publications presented to societies such as as ours; however, the explanation may be that publication of such work may not be permitted.

In the Department of Agriculture there are four appointments which are graded as research chemists, one in the Veterinary Research branch, one in the Division of Chemistry, and two at Schools of Agriculture, the salaries of the latter being in 1918, as previously mentioned, £285 and £320 per annum. A contrast with the research activities of the Department of Agriculture in the United States of America is decidedly startling. In 1913 the United States had ten great scientific bureaus each actively prosecuting research in the different branches appertaining to agriculture; the sum spent on printing alone in this year amounted to approximately £100,000.

Further, there were no less than sixty-four experimental stations throughout the country, each engaged in agricultural research, chiefly relating to the neighbourhood in which it was established. Can we wonder at the frequent complaints made at every farmer's congress about the utter inadequacy of the Government staff to conduct fundamental investigations?

At the beginning of this year a Research Grant Board was constituted by the Government, and its decisions in connection with applications for research scholarships and grants-in-aid of research in respect of the year 1919 were recently announced.

A sum amounting to £1650 has been allocated among eighteen successful applicants, made up of seven scholarships, amounting to £860, and eleven grants-in-aid of a value of £790. The position as regards chemistry in the list of awards is disappointing as only one deals with a chemical problem.

The Royal Society of South Africa also annually administers a research grant of a value which, while I have not the correct figures, does not exceed £1000.

It will have been noticed recently that the British Government has established a department for scientific and industrial research, while a grant of £20,000 is being arranged for. This sum is to be expended in stimulating scientific research with a view to developing the economic resources of the Colonies and Protectorates during 1919 and 1920 and the four following years. The Union Government has been asked to furnish a brief review of the present position of affairs. It must unfortunately be necessarily a brief one!

The mineral industry of the Union is the accepted backbone of the country, and according to the recent reports of the Department of Mines and Industries the value of the mineral output during 1918 amounted to £47,737,738, made up chiefly of the following items:—

Gold	£35,759,003
Diamonds	7,114,867
Coal	3,224,597
Tin	440,995
Copper	342,105
Silver	187,608
Salt	163,722
Lime	158,245

The magnitude of these figures is sufficient excuse for a plea for the establishment of what may be termed a "Bureau of Mines," to be conducted on lines similar as far as applicable in this country to the institution of that name conducted under the Department of the Interior of the United States of America. This Bureau was established to conduct, in connection with the public welfare, fundamental inquiries into the mining, metallurgical, and mineral industries. Those who have followed its labours know the importance and value of its investigations. In 1913 the money voted to it amounted to £132,400, of which approximately £70,000 was devoted to technical research pertinent to the mining industry.

A similar institution in this country would be responsible for enquiries of a like character, and would conduct research work in connection with problems such as miner's

phthisis. This subject has been considered by many Commissions as well as Select Committees of the House of Assembly since 1904, but no real investigational work was carried out until 1912, when the Miner's Phthisis Prevention Committee, which consisted essentially of technical men, was formed. Commissions of necessity must consist of partisans, and the result is that majority and minority reports are the rule and not the exception. The pronouncement of a body such as the Bureau on this and similar subjects supported by a mass of scientific data, would be of such a nature that its finding must be accepted and given effect to by legislation. Hinged closely on the question of phthisis is the carrying out of the routine analyses necessary for the control of noxious gases and dust in mine air. It is surely anomalous to find that such an important and vital matter is left entirely to the mine authorities, who, however, hedged round by regulations, will not always, in the records which they are obliged to keep, reflect the true ventilation conditions of the mine if that be bad. I say this advisedly. The regulations lay down definite figures for the permissible limits of noxious gases, but I have yet to learn of prosecutions for non-observance, at any rate within the past few years. The responsibitity for the observance of the regulation lies with Government, and it cannot shirk its responsibilities by placing the onus on the mine authorities. This obligation is accepted in connection with the other regulations, as is instanced by the appointment of mining and machinery inspectors.

The duties of the Geological Survey could most appropriately come under this Bureau, and would result in a great co-ordination of work.

In 1914, in addressing you, Prof. Stanley urged that the Governmsnt should make provision for the conduct of metallurgical investigations of refractory ores, and instanced the facilities which already existed for this purpose. Such investigations could most suitably be carried out by the Bureau.

Many other instances where the Bureau could prove its usefulness must occur to you.

As a rough outline of the method of working the Bureau I would suggest that it be divided into routine and research departments, each under a deputy-director who would be directly responsible to the director in charge of the Bureau. The appointment of the staff would create no difficulties, but the emoluments offered should be of a nature that really competent men would be obtained.

As a scientific society we are deeply concerned in the qusstion of education and have shown in the past great interest in this matter. The formation of a university in our midst where facilities will be afforded for a comprehensive training in Science, Arts, and Commerce is a matter for congratulation, and we welcome the donations which have been given towards this object, and look forward with confidence to the time when the example which has been set will be excelled by those whose wealth has been acquired by the application of scientific knowledge to the industries of the country. Cicero said, "What greater gift or better can we offer to the State than if we teach and train up youth?" These words are true to-day.

It is interesting to remark how donations and bequests to universities and other educational institutions have been given in other countries by those who have been able to appreciate and apply science to their business, and realise the necessity for its encouragement.

A donation of £218,750 was recently made to Cambridge University by members of the British Oil Companies for the purpose of the establishment of a definite and detailed course of education, particularly for chemical students. This satisfactory recognition of the value of chemistry is extremely gratifying, and gives a lead to those who are indebted in a similar manner to science. We also learn that another bequest of £200,000 was made to the Queensland University by the late Sir Samuel McCaughey. The local example of the late Mr. Beit, whose bequest of £200,000, as we are all aware, was filched from us probably owing to our delay in dealing with it, should also act as a stimulus.

The nucleus of the university is here, and shall it be said that we were so neglectful of our own interests that we let it languish? Posterity will be our judge, and it is for those who have the wealth to ensure that the verdict will be a favourable one.

In the quarter-century which has elapsed since the formation of our Society, South Africa has advanced to a position which now enables her to take a worthy place among the nations of the world, and it is for us all to do our share in seeing that she maintains that proud position. It is our heritage won by the sacrifice of those who have gone, and it behoves us to do nothing to tarnish the lustre of their bequest but to make South Africa's position more secure, more prominent, more brilliant, and to pass on to our sons in our turn a talent which we have not buried.

As a Society we can play a great part in the future industrial expansion of the country. Our record is bound up with the history and development of the gold mining industry, and is one in which we have cause to feel proud. There is no reason why in the future we should not take the same prominent part in other directions and in fostering other industries through chemical knowledge.

PRESIDENTIAL ADDRESS TO THE SOUTH AFRICAN ASSOCIATION OF ANALYTICAL CHEMISTS.

By Professor J. A WILKINSON, M.A.

The years which have passed since the foundation of this Society constitute one of the most momentous periods in the history of the human race. Its birth witnessed the full noontime of peace, progress, and prosperity amongst all the nations of the earth, but these in one country, where the cult of our profession had at that time become famous, were manacled to the chariots of an autocratic despotism, which aimed at placing beneath its wheels nought less than the human race itself. The apotheosis of war, as a dogma for the betterment and progress of humanity, as a creed, and, when necessary, a weapon of merciless savagery and insatiable lust for its rulers, has, we now hope, been consigned for ever to the realms of the past. The multitude of recent wars which have encompassed the earth and vindicated the fundamental and elementary rights of humanity, have now happily ceased to be, and the dawn of peace is once again radiant in all its hopeful joyousness.

The foundation of this society saw the spectacle of a world but coolly interested in the profession of Chemistry. In the troubles and trials of the struggles which ensued, loud and eager were the calls for its co-operation and assistance. The response, which it so readily gave, has proved its redoubtable claims to the highest rank amongst the professions, a necessity in peace no less than in war, a factor which can no longer be thrust aside or lightly treated, a postulate without which progress is impossible.

The statement has often been made that the present moment marks the commencement of a new era in the world's history. If so, it should be a matter of interest to pass in review some of the events which have contributed to a better understanding of our work by the public generally, and incidentally have served to bring about a closer union within the profession itself.

In the closing years of the last century the eminent English chemist, Sir William Crookes, emphasised the fact that the oceans of gaseous nitrogen in the atmosphere were incapable of utilisation by plants except to a negligible amount. At that time the Chili saltpetre beds and the nitrogen of coal obtained in the form of ammonium sulphate were the two chief simple nitrogenous fertilisers utilised as plant foods, but with the calculated increase in the world's population it appeared that th

quantities of these fertilisers obtainable would soon prove to be insufficient to raise the wheat which would be required to sustain the increased population. Hence the problem arose of converting the atmospheric nitrogen into some solid form, such as either of those already in use.

The first decade of the present century witnessed the solution of this problem in several ways, the sole object being the conversion of atmospheric nitrogen into plant food, in order that man might live. Industries of huge dimensions arose in Scandinavia and Italy, with a yearly output of thousands of tons of solid nitrogenous manures.

At the beginning of the second decade another solution of this problem was worked out by Prof. Haber at Carlsruhe, in Germany, namely, the direct conversion of the nitrogen into ammonia, and at the same time Prof. Ostwald, of the University of Leipzig, brought to completion his studies on the oxidation of ammonia to nitric acid. Experimental operations on the large scale were carried out by the Badische Co., at Oppau, and, though difficult and hazardous, proved successful about the middle of 1914.

This enabled Germany to prepare unlimited quantities of the nitric acid required for the manufacture of the high explosives required in war, such as picric acid, trinitrotoluene, tetranitro-aniline, &c., by processes of her own and from materials within her own borders, and thus render herself independent of other countries whence formerly she had drawn her supplies. The last and perhaps the most important stage of the preparations for war had been attained, and the die was now ready to be cast at the first opportune moment.

At this time, according to Prof. Vignon, of Lyons, the number of chemists were for every 300 in Germany, seven only in France, and in Britain six!—these figures being based upon the 1910-11 population of these countries, namely, Germany 65 millions, France 40 millions, and Great Britain 45 millions approximately. These reflect to some extent the state of the development of chemical industry in these countries, which had resulted in the capture by Germany of a world trade in dyes, drugs, photographic and other highly specialised organic chemical products, and a factory organisation such as no other country could show. When in 1914 the dogs of war were let loose, these giant installations of chemical plant were at once available for the manufacture of explosives and the newest weapon of death invented by our enemies, poison gas. Lord Moulton, in a recent speech at the Annual Dinner of the Society of Dyers and Colourists, at Bradford, said that as Director General of Explosive Supply he had to name a Commission to visit and report on these factories along the Rhine, and what he had read in their reports and what they had told him in discussions had filled him with dismay. These great Chemical industries had been making devilish poison gases in quantities, as great as even Germany could want, with the plant they had ordinarily used for chemical products without changing one single item of plant.

The fact of Germany's pre-eminence in organised chemical industry was a matter of common knowledge before 1914, but the multitudinous uses, to which these factories could be immediately converted in case of the urgent necessities developed by a state of war, had not been generally realised. Gradually, however, as the war proceeded enlightenment came not only to those elected to rule it conduct, but also to the man in the street.

The former were dismayed first at the prodigality of the amount of high explosives used by our enemies, and secondly by the use of poisonous gases, whilst the public found itself deprived of its favourite drugs and dyes, as well as many other chemical products essential to its well-being. By heroic efforts and without counting the cost, England set to work to remedy the defects in her armour, and that she accomplished the feat with success is now too well known to call for comment.

For this achievement an army of chemists was called into being, and chemical industry expanded to dimensions which exceeded even the wildest imagination. The utterly vital necessity of the chemist's work had at last been fully realised both by the nation and its leaders. As far as the chemists themselves were concerned, the result was equally fruitful, since for the first time they felt as a body the need for closer fellowship and co-operation, in order that their work and the position to which that work entitled them might received the recognition which it merited.

(To be continued).

PROCEEDINGS OF SOCIETIES.

INSTITUTE OF CHEMISTRY.

(Liverpool Section).

The First Annual Dinner of the Section was held at the Midland Adelphi Hotel on December 5, 1919. Mr. G. Watson Gray, Chairman of the Section, presiding.

The guests included Sir Herbert Jackson, President of the Institute, Mr. Alderman William Muirhead, Chairman of the Health Committee of the Liverpool Corporation, and Mrs. Muirhead, Mr. David Cardwell, Hon. Secretary of the Manchester Section, and Mrs. Cardwell, Mr. Richard B. Pilcher, Registrar of the Institute, and Mrs. Pilcher.

After the loyal toasts had been proposed from the Chair and duly honoured, Mr. John Gray, President of the Society of Chemical Industry, proposed the toast of "Liverpool, its Industries and Commerce." Mr. Gray referred to the important industries of the city and neighbourhood, especially the heavy chemical industry, remarking that this country had less to fear from foreign competition than from the uncertain position of labour matters at home. In any case, chemists would have to keep abreast of the times in the processes and methods of manufacture.

Mr. Alderman Muirhead, in reply, referred to the importance of motor transport in the trade and commerce of the city, and the necessity for road improvements, the cost of which will fall on the ratepayers. On the question of labour, to which Mr. Gray had referred, he thought it would be a good thing to endow a Chair at the University for the purpose of teaching trade union leaders something of the principles of political economy; for production was the only way to prosperity, and the limitation of production was distinctly opposed to progress. A system of grading was necessary, and trade union leaders should recognise that some were able to do a larger amount and higher quality of work than others. Every man should be entitled to do his best according to his ability. For the greater prosperity and well-being of the city he felt there was a need for closer co-ordination among local authorities and boards.

Next, Alderman Muirhead proposed the toast of "The Institute," expressing his appreciation of the valuable services rendered by chemists in public affairs—such as the protection of food and water supplies as well as in industry. Great progress had been made in chemistry during the past thirty years. The chemist was a necessary adjunct in modern industry. Co-operation with the engineer was also highly desirable, especially in relation to problems affecting the utilisation of waste substances.

Sir Herbert Jackson, in response, congratulated the Liverpool Section on its formation, its organisation, its activity, and its chairman. He believed that the Liverpool Section was the first to be formed and the first to hold an Annual Dinner. He referred to the aims of the Institute, its growth, and the development of its work, especially in the formation of a great professional body composed of trained and competent chemists and maintaining in the practice of the profession of chemistry the highest integrity in efficiency. He wished the Liverpool Section every possible success and prosperity.

Mr. William Doran proposed the toast of "The Ladies," to which Miss Muriel Roberts responded.

Mr. Hanley then submitted the toast of "Our Guests." He referred with regret to the unavoidable absence of Lady Jackson, to whom the Section had intended to present a bouquet which, under the circumstances, would be transmitted to her through the kind help of Mrs. Pilcher. He was sorry also that Mr. Grant, Chairman of the Manchester Section, was unable to be with them.

Referring to the remarks of the President, he thought it only fair to say that the initiatory steps towards forming a section had first been taken at Manchester, and he was glad to acknowledge the fact, although the Liverpool Section had been the first actually formed. The Section cordially welcomed its guests, appreciated very much their coming to the first public function of the Section, especially the President, the Registrar, and Mrs. Pilcher, who had travelled from London for the purpose.

The Registrar, in reply, said that the Institute was at all times anxious to be of service to the sections and to the members individually. Gatherings such as that promoted a good understanding between headquarters and the sections. He paid a tribute to the work of Mr. John Hanley, the Hon. Secretary of the Section, and expressed the hope that members of the Section would call at the Institute when they came to London. He hoped the accomplishment of Mr. Alderman Muirhead's proposals would render the journey easier. It was a graceful compliment to ask the ladies—he was sure that they were very pleased to be present. On behalf of all the guests he thanked the Local Section very heartily for the toast, for their cordial welcome, and their kind hospitality.

Mr. David Cardwell, Hon. Secretary of the Manchester Section, then proposed the toast of "The Liverpool Section of the Institute, its Chairman, and its Honorary Secretary," and in doing so complimented the Section on its activity, and particularly on the success of its first Annual Dinner. It was an excellent idea to hold such a function, and to bring the work of the Institute and of chemists to the public notice.

Mr. G. Watson Gray, the Chairman, in response, said it was the aim of the Section to help the Institute and the Council in every way possible; the Section was making good progress, and he hoped that the dinner was the forerunner of many similar happy evenings.

Mr. Hanley also replied.

An excellent programme of music was provided by Mrs. John Hanley, Mr. Lloyd Moore, Mr. Doran, and Mr. W. F. Hughes, to whom hearty thanks were accorded, on a motion from the Chair, before the company separated.

NOTES.

His Royal Highness the Prince of Wales has consented to preside at the Anniversary Dinner of the Royal Commercial Travellers' Schools, to be held in London in January next, and the Board of Management are desirous of marking this unique event in the history of the Schools by announcing a record list of subscriptions. To achieve this result the services of a large number of Stewards are needed, and I would appeal through the medium of your valuable paper to the travellers in your trade to volunteer for the work. A prompt reply will be greatly appreciated as time is short.—W. P. Lees, Sec., 17, Cheapside, E.C. 2.

Potassium Compounds.—Potash is chiefly used in the manufacture of fertilisers, but it is also employed to a considerable extent in certain branches of industry; in the manufacture of glass, dyes, soap, explosives, and matches. Before the war the United Kingdom, and indeed the whole of the world, was entirely dependent for its supplies of potash salts upon Germany, which enjoyed almost a monopoly of production owing to its great natural deposits at Stassfurt and in Alsace. When supplies were cut off by the war it was possible, though almost always with serious disadvantages, to use substitutes in some industries, but this was not practicable in all cases, and agriculture especially was very adversely affected. During the war a process for the production of potash from material originating in this country was brought into operation with very good prospects of success, but there have been great difficulties in the way of its development, especially inasmuch as the process involved extending plant or works already most severely taxed to meet the demands of war. The industry thus is as yet by no means firmly established, but there is good reason to hope that if the industry be afforded a period of reasonable protection, our dependence on foreign sources of supply for these highly important compounds will be largely mitigated, if not entirely removed.

Tungsten Powder and Ferro-Tungsten.—Tungsten powder and ferro-tungsten are required in the manufacture of high-speed steel. Ordinary tool steel, which contains no tungsten, loses its temper and its hardness and so becomes incapable of cutting if it be heated to a temperature well below incipient red heat. As a result the cutting speed of ordinary tool steels is limited to that below which the heat produced is sufficient to draw the temper or produce this softening. By adding tungsten to the steel in quantities up to as high as 20 per cent (but generally not exceeding some 15 or 16 per cent and even less), the steel is changed in quality in such a way that it does not lose its hardness at a dull red heat. Cutting operations can then be carried on at an increased speed, and the output of all machine tools built sufficiently strong to withstand the increased stresses, can be increased to about two and a-half times that possible when ordinary carbon steel is used. This property of tungsten is, of course, enormously valuable in all cases where output is of paramount importance, and in carrying out the shell programme its use was almost essential. Tungsten steels are also required in the manufacture of magnets for magneto-electric ignition machines and other purposes. The tungsten is added to the steel in the form of tungsten powder and ferro-tungsten. Before the war, although attempts had been made to carry on the industry in England, they always failed by reason of German competition, and, in fact, before the war Germany supplied practically the whole world with tungsten powder and ferro-tungsten—this notwithstanding the fact that the richest mines were in British territory. During the war the manufacture was successfully established in this country, and its importance was deemed so great that it was started in many other countries also, notably America, France, Italy, and Japan. In addition to the form of tungsten powder just considered, there is another particularly pure form of tungsten powder which is required in quite small quantities for compressing into slugs and hammering out into solid tungsten objects, such as electrodes for wireless valves, X-ray tubes, &c. These slugs are also drawn down into tungsten wire used in the manufacture of metallic filament lamps. The British output of this particular form of very pure tungsten is not at present up to requirements, though it is hoped that very shortly we shall be able to meet our own needs and also carry on an export trade.

At the meeting of the Chemical Section of the Manchester Literary and Philosophical Society, held on Friday, November 28, 1919, the following officers and members of committee were elected:—Chairman, Mr. R. H. Clayton; Hon. Treasurer, Mr. J. H. Lester; Hon. Secretary, Mr. F. W. Atack. Other members of Committee—Dr. Edward Ardern, Mr. H. J. Bailey, Mr. Percy Bean, Dr. W. H. Bentley, Mr. Joseph Brewerton, Mr. David Cardwell, Dr. H. F. Coward, Mr. J. B. Cullen, Dr. R. B. Forster, Dr. H. G. A. Hickling, Mr. W. B. Hart, Mr. Francis Jones, Prof. Arthur Lapworth, F.R.S., Mr. T. G. G. Marsh, Mr. S. E. Melling, Prof. F. L. Pyman, Mr. L. Guy Radcliffe, Miss Rona Robinson, Mr. W. Scott Taggart, Mr. Leonard E. Vlies, Mr. J. A. Weil, and Mr. T. R. Wollaston.

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THE CONSTITUTION AND STRUCTURE OF THE CHEMICAL ELEMENT.

By HAWKSWORTH COLLINS

IT is well known that single electro-positive charges emanate from masses of 1 (hydrogen), 7 (lithium), 23 (sodium), and 39 (potassium); also that two electro-positive charges emanate from 4 (helium), of which one has been shown to emanate from a mass of 3; therefore it is evident that single charges emanate from each of the following masses:—1, 3, 7, 23, 39.

And it has been shown that the difference between the total number of electric charges (the atomic number) and the maximum valency is an even number; so that it is evident that the charges are quiescent in pairs.

Also it is evident from experiments on radio-activity, which are frequently quoted in the CHEMICAL NEWS, that an electro-negative charge is converted into a positive charge by the emission of a β-ray, so that a negative charge is potentially a positive charge, and is only negative under certain conditions which will be evident later.

With the above facts as the main data together with several other facts which have been proved to be true in the CHEMICAL NEWS (July 18, 1919, and November 28, 1919), it is now possible to solve the mystery involved in the integers representing the atomic weights of the first 26 elements.

Twenty of the 26 are shown in Table I. with their atomic weights split up in a uniform manner. The six exceptions will be brought in later.

TABLE I.

	At. wt.		Number of parts into which at. wt. is divided.	Max. val.
H ..	1 =	1	1	1
H_3 ..	3 =	3	1	1
He ..	4 =	1+3	2	2
Li ..	7 =	7	1	1
B ..	11 =	7+1+3	3	3
C ..	12 =	7+1+3+1	4	4
Na ..	23 =	23	1	1
Mg ..	24 =	23+1	2	2
Al ..	27 =	23+1+3	3	3
Si ..	28 =	23+1+3+1	4	4
P ..	31 =	23+1+3+1+3	5	5
S ..	32 =	23+1+3+1+3+1	6	6
Cl ..	35 =	23+1+3+1+3+1+3	7	7
K ..	39 =	39	1	1
Ca ..	40 =	39+1	2	2
Sc ..	44 =	39+1+3+1	4	4
Ti ..	48 =	39+1+3+1+3+1	6	6
V ..	51 =	39+1+7+1+3	5	5
Cr ..	52 =	39+1+7+1+3+1	6	6
Mn ..	55 =	39+1+7+1+3+1+3	7	7

There are no less than five distinct coincidences in this method of splitting up the atomic weights of these 20 elements.

1. Each element is split up into as many parts, 1, 3, 7, 23, 39, as the element has valences.

2. All the portions of the elements are represented by odd numbers.

5. The non-metallic elements are distinguished from the metallic by the presence of one or more portions (1+3) (helium).

4. Electro-positive forces are distinguished from electro-negative forces by the following rule:—An electro-positive force emanates from each of the masses 1, 3, 7, 23, 39, except when an element has one or more portions (1+3), in which cases electro-positive forces emanate from these portions, whilst electro-negative forces emanate from each of the remaining portions of the element.

5. Hydrogen forms the connecting link in the structure of these elements.

With regard to the first coincidence some people may think it is easy enough to split up the atomic weights of these 20 elements in this manner, but if the atomic weight of each one of them be raised or lowered by unity not a single one could be thus split up. For instance, if the atomic weight of Mn were 54 instead of 55 it is impossible to split the former number up into seven parts in any way, whatever using any or all of the numbers 1, 3, 7, 23, 39. And the same remark applies to all the 20 atomic weights when increased or diminished by unity.

The probability that the first coincidence has happened by accident is 1 : 2^{14}, taking into account the six exceptions, Gl, N, O, F, Ne, and A.

This is obtained in the following manner:—If there had been no exceptions the probability would have been 1 : 2^{26}, with one exception 1 : 2^{24}, and so on, and therefore with six exceptions 1 : 2^{14}. But since some people may like to exclude H_3 and Sc, the probability becomes 1 : 2^{10} = 1 : 1024; say, 1 : 1000.

And in the same way the probability that each of the third, fourth, and fifth coincidences has happened by accident is 1 : 1000. Therefore the probability that the five coincidences have happened together by accident is 1 : 1000^4 = 1 to a billion; *i.e.*, the probability that these five coincidences contain a truth is 1,000,000,000,000 : 1. But the probability is much greater than this really, because some of the coincidences are not by any means simple.

Even if scientists objected to one or two small details in the facts upon which this reasoning is based, still it is evidently a matter of infinite probability; *i.e.*, it is certain that the matter contains a truth.

But from what follows it will be seen that the matter is much more certain even than this, because four of the apparent exceptions demonstrate a deeper truth, only two, Gl and N, being real exceptions.

If we include O, F, and Ne in the table, arranging their parts so that they fall in with the symmetry of the table, they will appear as follow:—

TABLE II.

	At. wt.		Number of parts into which at. wt. is divided.
O ..	16 =	7+1+3+1+3+1	6
F ..	19 =	7+1+3+1+3+1+3	7
Ne ..	20 =	7+1+3+1+3+1+3+1	8

Here oxygen is divided into six parts, F into seven, and Ne into eight, and it is necessary to remember that O falls in the Periodic Table in a column where all the elements except itself have a valency of 6, and F falls also in a column where every element except itself has a valency of 7, and Ne falls in a column where the valency would be expected to be 8, but becomes reduced to zero owing to the union of four pairs of strong forces. So the question arises:—Is there anything in the tables which distinguishes these elements from the remainder? The answer is in the affirmative, for only in these cases are the metallic portions not greater in mass than the non-metallic.

The metallic portion of oxygen is 7+1 = 8, and its non-metallic portion is 3+1+3+1 = 8.

The metallic portion of F is 7, and its non-metallic portion is 1+3+1+3+1+3 = 12.

The metallic portion of Ne is 7+1 = 8, and its non-metallic portion is 1+3+1+3+1+3 = 12.

So that it is possible now to bring the facts with regard to 23 out of the 26 elements under one generalisation as follows:—Each of the atomic weights of 23 of the first 26 elements can be split up into as many portions, 1, 3, 7, 23, 39, as the element has valences in a uniform manner, but when the sum of the portions (1+3) helium) of an element is not less than the remaining portion the valency of the element is reduced by as many pairs of valencies as the element has "helium" portions.

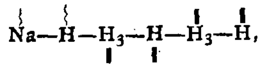
Two new coincidences are now evident from the tables.

6. The longer the string of $H-H_3$ the greater is the volatility of the element, ceteris paribus.

7. The longer the string of $H-H_3$ the stronger are the electro-negative forces from the metallic portions, ceteris paribus.

In the case of neon these two forces are so strong that they unite, making neon an inert gas; or two atoms unite and become atomised to form another inert gas, argon.

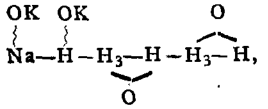
The constitution and structure of an atom of sulphur, as an example, may now be given as follows:—



where Na stands for 23, H for 1, and H_3 for 3, the thick lines representing electro-positive charges, the curly lines electro-negative charges, and the thin lines representing forces which are not chemically evident, and which have to be overcome before the atom can be disintegrated.

The atomic number of Na has been shown to be 11, and the atomic numbers of H and H_3 have both been shown to be 1, making that of S 16, so that the above diagram for sulphur shows the connection between atomic weight, atomic number, an maximum valency, distinguishes between electro-positive and electro-negative charges, and as a whole gives the constitution and structure of the atom, which has been proved by the mathematical theory of probability to be true.

The molecule K_2SO_4, *e.g.*, may then be represented as follows:—



he two electro-negative forces of O combining with the two electro-positive forces of each "helium" portion, and a base OK combining with each of the electro-negative forces.

THE OXIDATION OF LAVA BY STEAM.

By J. B. FERGUSON,
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CRYSTALS of olivine and other iron-bearing minerals are found associated with glass in the normal Kilauean lava, and some years ago the question arose as to whether their presence might be taken as evidence bearing upon the probable water content of the volcanic exhalations. Preliminary experiments made at that time by the writer indicated that the lava was not appreciably attacked by water vapour at temperatures in the neighbourhood of 1000° C., and that the presence in the lava of so much iron in the ferrous condition was not at variance with the water content of the emanations observed by Day and Shepherd. (See Day and Shepherd, "Water and Volcanic Activity," *Bull. Geol. Soc. America*, 1914, xxiv., 602; Smithsonian Report for 1913, 302, Publication 2286; Shepherd, *Bull. Hawaiian Volcano Obs.*, vii., July, 1919). These experimental results, obtained in 1912 and 1913, are now presented as a matter of record.

Most of the writers who have speculated upon the rôle that water plays in the chemical reactions which take place in the volcanic vent during an eruption have based much of their speculation upon the equation $3FeO + H_2O \rightleftharpoons Fe_3O_4 + H_2 + 15400$ cal. (Chamberlain, Carnegie Publication No. 106, lxvi., 1903; Daly, "Igneous Rocks and their Origin," 1914, p. 272; Von Wolff, "Vulkanismus," 1914, i., p. 116). This equation must not be taken too literally, because recent investigations have indicated that the action of steam upon a ferrous iron oxide at high temperatures gives rise to a "magnetite" of variable composition (Hilpert and Beyer, *Ber.*, 1911, xliv., 1618). The actual composition obtained is dependent upon the temperature. (The whole problem of the various oxides of iron is an exceedingly difficult one to study experimentally, and much yet remains to be done before the problem can be considered satisfactorily solved).

An analysis of a fresh flow of Kilauean lava shows 9·28 per cent FeO and 1·92 per cent Fe_2O_3 (Ferguson, *Am. Journ. Sci.*, 1914, xxxvii., 400, Analysis B). The ratio of ferrous to ferric iron in this rock is much greater than the ratio in magnetite (1 : 2), and, were we dealing with the pure oxides only, this fact might be used as an argument against the presence of a preponderance of water vapour in the gas phase. The lava, however, does not contain ferrous oxide as a separate phase. The ferrous iron exists mainly in the silicate minerals and the glass, together with a little in the traces of magnetite which are probably present, although microscopic examination does not show appreciable amounts of Fe_3O_4. The equations which would represent the reaction between water and the ferrous iron in the silicates might be quite different in character from the equation given for the pure oxides, and an assumption of analogous behaviour in these cases appears to be a somewhat risky matter.

(Such an assumption appears to have been made by Brun, who states that water vapour directly oxidises the ferrous silicate to magnetite. His statement is not confirmed by analyses of the solid products after reaction with water, but rests on the change in colour of the rock and the presence of hydrogen, together with CO and CO_2, in the gases evolved—*Arch. Sci. Phys. Nat.*, 1916, xli., 404).

Indeed, Thaddéef's results upon the oxidation of olivine by ignition in air indicate that the oxides are much more easily oxidised than is the ferrous iron of the olivine (*Kryst.*, 1896, xxvi., 77). He found that only two-thirds of the iron present in this silicate could be oxidised by such ignition, whereas it is common knowledge that ferrous oxide would be readily changed to ferric oxide under similar treatment (Sosman and Hostetter, *Journ. Am. Chem. Soc.*, 1916, xxxviii., 820).

My results qualitatively confirm the observations of Thaddéef in this respect, and were carried out as follows:—

Materials.—A piece of lava from the crater floor of Kilauea was crushed in a hardened steel mortar, and the part that passed the 20 but not the 40 mesh sieve (0·38—0·86 mm.), and also the part that passed the 200 mesh sieve (less than 0·074 mm.) were used.

The nitrogen was made from sodium nitrite, or by removal of oxygen from air by copper, and was passed through the usual purifying and drying train.

Apparatus and Procedure.—The furnace was a platinum wound resistance furnace of the type usually employed in this laboratory. The temperatures were determined by means of a platinum-platinrhodium thermoelement and a suitable potentiometer set-up. A long porcelain tube was placed in the furnace so that it projected 20 or 30 cm. out of the furnace at one end and 5 or 6 cm. at the other. The charge was placed in a platinum boat in the porcelain tube, and the boat had attached to it a stiff platinum wire which enabled one to insert the boat into the hot portion of the tube or to withdraw it into the colder portion at will.

For the steam experiments the steam-generating apparatus was attached to that end of the porcelain tube which projected 5—6 cm. from the furnace. This apparatus

Table I.—*Results of Experiments with a Kilauean Lava in Contact with Nitrogen and Steam.*

Expt. No.	Initial FeO content.	Final FeO content.	Gas employed.	Time of exposure. Hours.	Fineness of powder (meshes per inch).	Temperature. °C.	Percentage decrease in FeO.
1.	8·69, 8·69, 8·71	7·93	Nitrogen.	1	20—40	1000	8·8
2.	8·69, 8·69, 8·71	7·90	Nitrogen.	1	20—40	1000	9·2
3.	8·69, 8·69, 8·71	8·25	Nitrogen.	1	20—40	1000	5·2
4.	8·69, 8·69, 8·71	8·16	Nitrogen and steam.	2 (steam)	20—40	1000	6·2
5.	8·69, 8·69, 8·71	7·91	Nitrogen and steam.	2 (steam)	20—40	1000	9·1
6.	8·69, 8·69, 8·71	7·98	Nitrogen and steam.	2 (steam)	20—40	1000	8·3
7.	8·69, 8·69, 8·71	7·91	Nitrogen and steam.	2 (steam)	20—40	1000	9·1
8.	8·69, 8·69, 8·71	8·31	Nitrogen and steam.	1 (steam)	20—40	1100	4·5
9.	8·69, 8·69, 8·71	8·37	Nitrogen.	1	20—40	1100	3·8
10.	9·32	7·84, 7·80	Nitrogen.	1½	200	1000	16·1 (c)
11.	9·32	8·18	Nitrogen.	½	200	1000	12·2 (c)
12.	9·32	8·06	Nitrogen.	1	200	1000	13·5 (c)
13.	9·32	7·80	Nitrogen.	1	200	1000	16·3 (c)
14.	9·32	7·87	Nitrogen.	½	200	1000	15·6 (c)
15.	9·32	7·93 (*a*), 7·92 (*b*)	Nitrogen.	1	200	1000	14·9, 15·0
16.	9·32	7·95, 8·37	Nitrogen and steam.	1 (steam)	200	1000	12·5
17.	9·32	8·26	Nitrogen (0·1 mm. pres.).	½	200	1000	11·4 (d)
18.	9·32	7·95	Nitrogen (0·1 mm. pres.).	½	200	1000	14·7 (d)

(*a*) Top of charge.
(*b*) Bottom of charge.
(*c*) Air pumped out of charge and replaced by nitrogen before charge inserted into hot part of tube.
(*d*) Time for experiment two hours, including heating and cooling.

consisted of a boiler and pre-heater. The latter also acted as a trap for liquid water. The boiler had two valves, so that the water in it could be boiled for some time to expel all oxygen before an experiment was started. The rest of the apparatus was so arranged that it could be initially swept out with pure nitrogen, and then, after the steam had been shut off at the close of an experiment, could be again filled with nitrogen. The water that condensed in the cold portion of the porcelain tube was wiped out before the boat was withdrawn. During the wiping-out process and the cooling of the charge, an atmosphere of pure nitrogen was maintained.

Typical Experiment.—Five grms. of lava powder were placed in a platinum boat, and the boat placed in the cold end of the porcelain tube. Nitrogen was then admitted to the apparatus and all the air swept out. The boat was then pushed into the hot portion of the porcelain tube. The nitrogen was partly shut off and steam admitted. When a good flow of steam was obtained through the furnace the nitrogen was entirely shut off. The porcelain tube was so tilted that the water condensing in the colder portion of the tube, after passing the hot zone, would drain away from the furnace. After the experiment had run for the desired time, the steam was gradually replaced by nitrogen. The liquid water in the end of the porcelain tube was wiped out (a good flow of nitrogen prevented the access of air during this operation), and then the boat was withdrawn to the cold portion af the tube and, when cold, removed. A part of the charge was analysed for ferrous iron by the modified Pratt method, as used by Washington ("The Chemical Analysis of Rocks," 1910, 2nd edition, p. 136; 1919, 3rd edition, p. 186). Calcium phosphate, as recommended by Gage, was used to aid in the determination of the end-points in the permanganate titration (*Journ. Am. Chem. Soc.*, 1909, xxxi., 381). It should be noted that if any of the reducing gases present in the rock dissolved when the rock sample was brought into solution, they would be titrated and would appear as ferrous iron.

The results obtained in the experiments at atmospheric pressure and at a low pressure of nitrogen are given in Table I.

In addition, the results of two miscellaneous experiments are given below.

19. Some of the lava powder was heated in a platinum crucible in air over a Meker burner for two hours. The ferrous iron content was then found to be 1·94 per cent.

20. Some of the oxidised product obtained in Experiment 19 was heated in a partial vacuum (0·1 mm. of nitrogen) for four hours at 1100° C. The ferrous

iron value was then found to have been raised from 1·94 to 3·90 per cent. A duplicate analysis gave 3·87 per cent.

Discussion.—The results given in Table I. show that after heating there is a decrease in the ferrous iron content of the rock amounting, in terms of the ferrous iron originally present, to 4 to 9 per cent for the coarse powder and 11 to 16 per cent for the fine powder. The variations within each group are not traceable in any way to the gas phase present. In fact the steam appears to have acted like an inert gas.

(It cannot be argued that the gas reacted only with the surface material and did not penetrate the charge, for Experiment 15 shows that the samples from the bottom and top of the charge contain exactly the same amount of ferrous iron. Also it can hardly be argued that there was a surface attack upon the lava grains, since the results with both fine and coarse materials show the same independence of the gas phase, and the same final ferrous iron content).

Just what is the complete cause of the decrease noted is somewhat of a question. A certain apparent decrease in the ferrous iron content might be expected from the loss of the reducing gases which are liberated upon heating the lava, and some decrease might also arise from the taking up of some iron by the platinum boat (Sosman and Hostetter, *Journ. Wash. Acad. Sci.*, 1915, v., 293). An actual decrease would occur if part of the ferrous iron were oxidised by adsorbed gases. These effects would, however, be expected to be small.

The decrease in ferrous iron must therefore be ascribed mainly to some reaction within the lava sample itself. The magnetite which formed when the lava crystallised was probably the last material to dissolve during the decomposition of the sample with hydrofluoric and sulphuric acids, and if the formation of this mineral were at the expense of the oxygen in the remainder of the lava the analytical results would probably not indicate this but would rather show merely less ferrous iron. (After an experiment the material was found completely crystallised, although originally containing much glass). The mechanism of such a reaction within the lava, with the formation of magnetite, can only be speculated upon. Sosman (private communication; see also *Journ. Wash. Acad. Sci.*, 1917, vii., 58) has suggested the possibility of the presence of iron (Fe) in solution in the glass or minerals after this reaction. Another possible reaction would be the formation of a lower oxide of titanium than the TiO_2 usually reported.

The fact that both the fine and coarse material, although of slightly different initial ferrous iron content, contain practically the same percentages after treatment is probably traceable to the larger percentage of glass and smaller percentage of Fe_3O_4 in the fine material.

Whatever the cause of the small decrease in ferrous iron, and of the variations therein, the experiments leave no doubt that considerable ferrous iron, when in silicate combinations, can exist in the presence of water vapour at high temperatures.

The vacuum experiment (No. 20) with the oxidised material shows clearly the ease with which oxygen can be removed from such materials, and indicates that due regard must be given to this phenomenon, not only in the study of the chemistry of lavas, but also in the interpretation of the results obtained in experiments in which gases are pumped from rocks at high temperatures.

The data given in this article are of a qualitative rather than a quantitative character, and are not to be regarded as final data on the reactions of water vapour with iron-bearing silicates. The complete story cannot be obtained by experiments on so complex a material as a natural lava, but must be learned by experiments with simple silicates of known composition. These results are presented here, however, on account of their current interest and in the absence of any fundamental data on the reactions concerned.

The microscopic examination of the samples was made by H. E. Merwin, of this laboratory.

Recapitulation.

Under certain conditions steam is capable of oxidising iron and its lower oxides to magnetite, Fe_3O_4, or to ferric oxide, Fe_2O_3. This fact has often been quoted as an indication of the probable oxidising action of steam upon lava during volcanic activity. In this paper this reasoning from analogy is subjected to the light of recent investigations and found wanting. In addition, some experimental results are given which confirm the view that the ferrous iron is not thus oxidised, and indicate that the presence of much ferrous iron in the lava and much steam in the volcanic emanations of Kilauea are two facts which are in full accord. Several miscellaneous experiments are also reported which show that in the experimental study of the chemistry of the lavas careful attention must be paid to the character of the gas phase in contact with the lava if results of value are to be obtained. The bearing of these experiments upon the interpretation of the results obtained by pumping gases from rocks at high temperatures need only be mentioned.—*Journal of the Washington Academy of Sciences*, ix., No. 18.

STUDIES IN CONDUCTIVITY.

Notes on the Measurement of the Conductivity of Solutions.

By H. I. SCHLESINGER and F. H. REED.*

During the past few years a series of very thorough and valuable papers by Washburn and his associates on the methods and apparatus for measuring the conductivity of solutions has been published (*Journ. Am. Chem. Soc.*, 1916, xxxviii., 2431; 1917, xxxix., 235). Other papers by Acree and his students have also added greatly to our knowledge of the subject (Acree and Taylor, *Ibid.*, 1916, xxxviii., 2396). Nevertheless, a number of difficulties which we have encountered in the measurements required for our work on formic acid solutions have either not been touched on at all or have received only very scant attention as will be pointed out below. Since we have developed simple criteria for detecting the difficulties in question and simple methods for overcoming them, it has beee suggested to us that the publication of a *résumé* of these points would be of value to other workers in this field.

The resistance of the solutions was measured by the Wheatstone-Kohlrausch method, using a Siemens and Halske high frequency generator, a rotary bridge, and a standardised Curtis coil resistance box. The connections and the methods of shielding the apparatus are those recommended by Washburn and Bell (*Journ. Am. Chem. Soc.*, 1913, xxxv., 177; an excellent *résumé* of the Washburn apparatus is given by Leeds and Northrup, *Catalog*, 1915, xlviii.) In conjunction with the high frequency circuit we used a Leeds and Northrup condenser which permits of placing equal capacities in series with the two lines of the circuit; by means of a two-way switch this condenser could be eliminated, and readings taken without any capacity of the high frequency circuit. It was observed that the introduction of the condenser, while it improved the sharpness of the minimum, decidedly shifted its position, and that the shift thus produced depended on the type of resisting medium and the magnitude of the resistance. The shift was particularly large when the

* The work reported in this paper has been presented to the Faculty of the Ogden Graduate School of Science of the University of Chicago by F. H. Reed in part fulfilment of the requirements for the Degree of Doctor of Philosophy. This work was completed in the fall of 1916. From the *Journal of the American Chemical Society*, xli., No. 11.

usual Wheatstone bridge set-up, that is with the current entering at the ends of the bridge, was used. Thus, the introduction of the condenser did not shift the minimum when a resistance coil of approximately 300 ohms was measured against 300 ohms in the Curtis box, but with 400 ohms the minimum shifted from 0·5001 to 0·5005, and when a 1000 ohm coil was measured against a 1000 ohm Curtis coil from 0·5001 to 0·5013. It is seen therefore that when the type of the resisting medium remains the same the shift in the minimum increases with the resistance to be measured. But there is another factor involved, for when the coil resistance is replaced by a cell containing 0·01 N solution of potassium chloride, larger shifts are obtained even with smaller resistances. Thus in a cell in which the solution had a resistance of approximately 880 ohms, the bridge reading shifted from 0·2540 to 0·2589 with the condenser, while in another cell in which the resistance of the same solution was 1387 ohms, the reading shifted from 0·2238 to 0·2320. It is to be noted that even where the shift is very large, each reading was very sharp, the maximum error of setting being not greater than 0·0001.

It is of course necessary to eliminate such shifts. To do this we first determined the arrangements of the bridge, &c., which gave correct readings when two standardised Curtis coils (each of 1000 ohms) were placed in the two remaining arms of the bridge, and it was found that the results without capacity in the high frequency circuit were correct, whereas the use of the condenser produced the sort of shift described. In order to retain the advantages of having resonance on the circuit, and at the same time to avoid the difficulty described, we investigated the matter from an experimental point of view and found the following:—1. The shift could be completely eliminated by having capacities in the two sides of the circuit which were not identical. When, for example, the two capacities were respectively 0·0245 and 0·0225 microfarad, the shift was greatly decreased but not entirely eliminated. No further changes in capacity which could be produced by our Leeds and Northrup condenser made further improvement, but by using a small variable Clapp-Eastham air condenser in parallel with the smaller capacity we eliminated the divergence for all cases investigated. The setting of this condenser for our purpose made the total capacity for this side about 0·0228 microfarads. There is, however, a disadvantage in using this method of avoiding the difficulty; for when the capacities are adjusted to give correct readings for the case in which the shift is fairly great, the setting is also correct for any case where the divergence is smaller, but not necessarily so where it is greater. This condition necessarily leads to uncertainty in the results. 2. It was further found that when the bridge was arranged to have the telephone at the ends of the slide wire the shift was very much reduced. We shall call this arrangement "set-up A" while the arrangement usually used is called "set-up B." Thus, in the case in which with set-up B the bridge reading with equal capacities was 0·2320 and without capacity was 0·2238, the corresponding readings were 0·2234 and 0·2238 respectively for set-up A, and where set-up B gave smaller shifts than this, set-up A gave identical results with or without capacity. Furthermore, in the case of set-up A, when the capacities in the high frequency circuit were 0·0245 and 0·0225 respecttvely instead of equal, the introduction of the condenser into the circuit no longer produced any shift in the minimum, and gave the correct reading for every type and value of resistance measured by us. Small changes, such as would be produced by introducing the air condenser, have no effect on the readings with set-up A. This arrangement has, however, the disadvantage that a larger amount of current flows through the cell than with set-up B, and more heating of the solution results. This difficulty can be completely overcome by making an approximate setting, waiting until the solution returns to the bath temperature, and then making the final reading very quickly. It is also helpful to use a resistance in the box somewhat smaller than the resistance in the solution.

(That the readings as usually taken by us and the readings at the centre of the bridge gave identical results, with the set-up used, was repeately proven. We also found that the capacity of approximately 0·024 microfarads in the condenser was the amount required to produce resonance, and that making the capacities in the two sides of the circuit unequal did not materially decrease the current obtained).

The explanation of the results described can doubtless be found in some dissymmetry in the high frequency circuit before it reaches the bridge. (That the difficulty did not lie in an inequality of the capacities of the two two sides of the condenser was shown by a rough measurement of the capacities and by substituting two standardised capacities for the one we had been using). We were unable to locate it, and made no extended efforts to do so as we eliminated the difficulty by the method described. The reason why set-up A gives smaller deviations than does set-up B is probably because the arrangement of the bridge in the former is more nearly symmetrical, and consequently produces more nearly equal energy losses in the various arms of the bridge.

There is another source of possible error in measuring resistances of solutions which has not received the attention it deserves in the treatment of the subject. In the papers to which reference is made above the fact that the minimum may be perfectly sharp and yet may not be correct has been mentioned, but no stress has been laid on this important point. Acree, for example, has stated that one of the criteria for the reliability of a cell is that it must give for the ratio of the resistance of two solutions measured in it the same value as is found in some other cell. This may be put in other words by the statement that the cell constant must be the same no matter what standard solution is used to determine it. It is of course the usual procedure to determine the cell constant with more than one solution. But more than this is necessary to make certain that the cell in question is suited to the solutions whose conductivities are to be determined in it. It is essential that the standard solutions used to determine the cell constant have in the cell a range of resistance completely covering the range of the solutions to be measured in it. That this is not usually understood is demonstrated by the fact that the specific conductivities determined by Kohlrauch, which are usually employed as standards for the determination of cell constants, are not well enough distributed to cover satisfactorily every possible range of resistance. The data presented below will make this point clear.

In previous work on anhydrous formic acid a special form of Arrhenius cell with fixed electrodes, adapted to the measurement of fairly dilute solutions, has been employed (*Journ. Am. Chem. Soc.*, 1914, xxxvi., 1589). These cells have cell constants of approximately 0·2, as determined with both 0·02 N or 0·01 N solutions of potassium chloride. Since these cells are not well adapted to the measurement of concentrated solutions without the use of fairly large capacities in parallel with the bridge circuit, no further determinations of the cell constants were made at that time, as the only other Kohlrausch standards are fairly concentrated solutions. The more accurate measurements of the formate solutions required for the work to be reported in later papers gave reason to doubt the reliability of these cells and measurements of the cell constant with a larger number of solutions were carried out. For this purpose we used 0·01, 0·02, 0·05, and 0·2 N solutions of potassium chloride, and made the equivalent conductivities of A. C. Melcher, reported in the paper of Noyes and Falk, the basis of the calculation of the cell constant (*Journ. Am. Chem. Soc.*, 1912, xxxiv., 454). The data obtained for one of these "Arrhenius type" cells as well as for the two cells referred to by the symbols H_1 Fig. 1, and H_3 are given in Table I. The latter are cells of the kind which have been constructed for the later work on

formic acid solutions. Their construction will be sufficiently clear from Fig. 1. The electrodes are platinised. The cells are particularly well adapted to work where only a small volume of solution is available since 20 cc. of solution brings its level so high above the electrodes that the addition or removal of 1 cc. or slight tilting of the cell does not change the observed resistance. Furthermore, the readings are very sharp over wide ranges of concentration, and only small capacities are required in parallel with the bridge circuit in order to obtain excellent minima. (In the "Arrhenius type" cells, for example, a capacity of 0·18 microfarad had to be used in parallel with the bridge circuit to obtain a good minimum for small resistances, while for the type of cell here described the maximum capacity required for our solutions are less than 0·01 microfarad). Throughout a period of more than a year in which the cells were constantly in use the cell constants did not change, which shows that the support for the electrodes

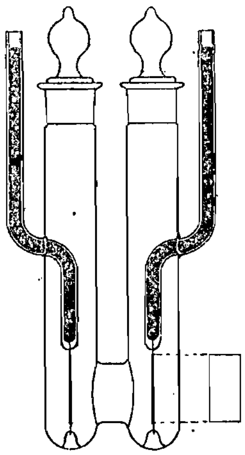

Fig. 1.

is sufficiently rigid. In the table mentioned above the solutions used, the measured resistance (R) in ohms, and the cell constant (C), calculated from the latter for each of the three cells, are given. The resistances are in each case the averages of very closely agreeing duplicates made with different solutions prepared from different samples of potassium chloride which had been recrystallised several times from conductivity water with all due precautions, and had then been ignited.

Table I.—*The Variation of Cell Constant with Increasing Resistance of the Solution in the "Arrhenius" Cell.*

KCl solution	Arrhenius cell.		Cell H_1.		Cell H_3.	
N.	R.	C.	R.	C.	R.	C.
0·01	142·38	0·2015	1391·1	1·9684	883·37	1·2501
0·05	30·25	0·2021	294·49	1·9682	187·12	1·2506
0·2	8·21	0·2040	79·25	1·9686	50·35	1·2509
0·02	72·77	0·2018	710·40	1·9707	451·21	1·2517

Leaving out of consideration for the moment the results obtained with the 0·02 N solution, we see that the cell constant of cell H_1 does not vary, and that the variation in cell H_3 is only *0·06* per cent. Hence we may conclude that we may use H_3 for solutions whose resistance in the cell lies between 79 and 1400 ohms and H_3 for resistances between 50 and 880 ohms. As a matter of fact, it is only the lower limit which is of importance. For some reason, which we are unable to explain, the 0·02 N solutions give divergent results; the only suggestion which we can offer is that there may be an error in the equivalent conductivity reported by Noyes and Falk. If we now examine the data for the "Arrhenius" cell we see that the cell constant undergoes an apparent change of over 1 per cent in the same range of concentrations which gave a maximum variation of only 0·06 per cent in the other cells, even although each reading in the "Arrhenius type" cell was very sharp, quite as sharp, in fact, as in the other cells. It is clear, therefore, that the "Arrhenius" cell is not adapted to the whole range of resistance covered by these solutions, although there is nothing in the individual readings to indicate this fact. The following data show, furthermore, that although the cell constant may be the same when calculated from the results obtained with solutions of different concentration the cell may, nevertheless, not be satisfactory unless the standard solutions cover the correct range of resistance. In the cells H_1 and H_3 the average of the ratio of the resistance of the 0·01 N to that of the 0·02 N potassium chloride solution is 1·9580. In the "Arrhenius" cell the ratio is 1·9566, which differs from the one obtained in the other cells by only 0·07 per cent. In other words, the cell constant of the "Arrhenius" cell calculated from the resistance of the 0·01 N solution differ hardly at all from that calculated from the resistance of the 0·02 N solution, and the unreliability of the cell would have been overlooked had only these two solutions been used. (Errors of the kind found in the case of the "Arrhenius" cells are doubtless due to polarisation).

Summary.

It has been pointed out that even though the minima obtained in the measurement of the resistance of solutions by the usual method may be perfectly sharp, the results may nevertheless be incorrect, and criteria for determining the reliability of the measurements and methods for overcoming some of the difficulties encountered have been suggested.

PRESIDENTIAL ADDRESS
TO THE
SOUTH AFRICAN ASSOCIATION OF ANALYTICAL CHEMISTS.

By Professor J. A. WILKINSON, M.A.

(Concluded from p. 293).

The first outward sign of this feeling manifested itself at Manchester on November 10, 1917, at a meeting of 600 chemists, when it was decided to form provisionally a British Association of Chemists with the following objects:—

(*a*) To obtain power to act as the sole registration authority for all chemists.
(*b*) To have the word "chemist" legally redefined.
(*c*) To safeguard the public by obtaining legislation ensuring that certain prescribed chemical operations be under the direct control of a chemist.
(*d*) To raise the profession of the chemist to its proper position among the other learned professions, so that it may attract the attention of a larger proportion of the best intellects, and thereby secure a supply of highly trained chemists adequate to the industrial needs of the country.

It was also decided to approach the Council of the Institute of Chemistry in order to explain the objects of this Association, and to express the opinion of this meeting, that those objects can best be attained by the Institute broadening its scope.

The work of the latter body for the profession since its inception in 1877 is too well known to members of this or any other society of chemists to need elucidation, but in its altogether laudable attempt to maintain a high standard it had been led to formulate rules which to some extent

defeated its own objects. Although its labours had been and still were such that no praise could be too great, yet there was but little doubt that it was not in complete accord with the feelings of the majority of chemists in Great Britain. Its functions coincided to a large extent with those outlined by the proposed new Association, and hence the decision to act in conjunction, if possible. The joint meeting of the executives was held on December 14 *in camera*, and at a meeting of chemists at Newcastle on January 12, 1918, the Registrar of the Institute spoke of the sympathetic attitude of the Institute towards the new Association, admitting at the same time that it had not touched the great body of chemists in the country.

Birmingham, Manchester, and Newcastle had so far approved the formation of the new Association, and London followed suit at a meeting on February 4. Meanwhile the Institute and the Association issued reports on the negotiations which took place on December 14, the chief provisions of which were briefly that the Institute would modify its regulations as follows:—

1. To admit as many chemists as possible to the membership, as far as compatible with the provisions of its charter.
2. That any candidate may apply for admission as Associate if he has obtained a first or second class honours degree or diploma in chemistry after a three years systematic day course in a recognised University or College, and either taken a further fourth-year course or two years under a Fellow of the Institute or in an approved laboratory or works, and produced satisfactory evidence of a training in physics, mathematics, and an optional subject, and has attained the age of twenty-one years.
3. That local centres be formed.
4. That the list of recognised Institutions be revised with a view to its extension.
5. That the system of election of Council be revised to provide greater freedom of nomination by the general body of members.

This action did not meet with the full approval of older members of the Institute, and opposition appeared from various quarters. Meanwhile, however, 299 War Associates were approved by the Council and admitted without examination.

Concurrently with the above a National Association of Industrial Chemists (*Journ. Soc. Chem. Ind.*, Feb. 28, 1918, p. 69) was formed at Sheffield with the following objects:—

(*a*) The economic, intellectual, and social advancement of industrial chemists and metallurgists.
(*b*) To promote the interests of its members by collective action.
(*c*) To further the interests of young chemists entering on professional and business careers.
(*d*) Education.

From a speech delivered by the President in September, the first step in the policy of the Association is to obtain by legitimate means due recognition of the works chemist in the industrial life of the nation, one method of effecting this being to see that he obtains representation on Government Industrial Committees which are now composed mainly of employers and members of various trade unions. A second method will be to use every legitimate means to ensure adequate financial remuneration. Further, every assistance will be given to chemists who make discoveries and effect improvements to enable them to obtain just recognition of their work; and an employment register will be opened. "It is understood that local sections have been formed in Sheffield, London, Birmingham, Middlesbrough, Newcastle, and Scunthorpe, and that the number of members is approaching four figures, including many with academic qualifications." By the end of March the British Association of Chemists had ten local sections in operation or process of formation, but neither this body nor the Institute of Chemistry was desirous of constituting itself the registration authority. On April 27 an extraordinary General Meeting of the Institute was held at King's College, London, and the resolutions embodied in the report of the meeting with the British Association of Chemists were passed. At the same time it was stated that committees would also be formed, when necessary, to represent the interests of special branches of the profession; the provision for the registration of students would be reconsidered; steps would be taken towards closer co-operation between the work of the Institute and that of the Universities and Colleges; the question of extending the publications of the Institute would be revised; further, endeavours would be made to bring before the public the importance of chemistry to the country and generally to forward the interests of chemists in every way possible.

The attitude taken up by the Institute was considered so effective, that proposals were made by the executive of the British Association of Chemists to its local sections that it cease to exist as soon as convenient after local sections of the Institute had been established. These met with support from some sections and opposition from others, the main reason for the latter being the British Association of Chemists would include in its organisation large numbers of chemists who would be ineligible for the Institute's membership even under the new rules, since they would be incapable of fulfilling its requirements. The majority of the latter were technically trained chemists as opposed to those who had been trained in Universities, and until some provision could be made for them, with due regard to the preservation of the high standard jealously guarded by the Institute, it was felt that there was still work for the new Association to perform.

At a meeting held on June 15, 1918, at Manchester, it was reported that 1072 votes had been cast in favour of and 318 against the resolution that the Institute's proposals reasonably met the suggestions of the British Association of Chemists, also that 710 votes were in favour of the continued existence of the British Association of Chemists, and 642 against.

As a result resolutions embodying the following were carried by large majorities:—"That the provisional form of the Society be terminated, and the Executive be instructed to proceed with the definite formal organisation including the following objects:—

"(*a*) To keep a continuous and critical survey of the developments of the movement for the organisation of chemists.
"(*b*) The co-ordination with a view to federation, if found desirable, of all the organisations concerned with the profession and practice of chemistry.
"(*c*) To devote itself to those interests of chemists which are outside the scope of the Institute of Chemistry's activities."

Also that a register of members be prepared on the basis of the British Association of Chemists' accepted qualifications.

Mention should also be made of the Sheffield Association of Metallurgists and Metallurgical Chemists, which owed its inception to the determination of the scientific men engaged in the metallurgical industries to improve their professional status. The first formal meeting was held on February 4, 1918, with an attendance of about 200, at which the President delivered his inaugural address on the rules and objects of the Association, which latter are defined as follows:—

1. To provide an Association with local headquarters and a library in which chemists and metallurgists and others interested in the scientific side of the industries of the district may meet together.
2. To deal with local interests in any national or other movement having for its object the raising of the professional status of scientific workers.

3. In addition, the Association intends to co-operate with other similar organisations to form a National Applied Science Association.

With regard to the latter, it may also be noted that the National Union of Scientific Workers also sprang into existence about this time, with an organisation and aims similar to that "which the experience of the labour trade unions has led them to substitute for the older craft unionism."

Shortly after the war broke out the Association of British Chemical Manufacturers was formed, and is now fully representative of all the chemical industries. At the same time it is fully assured of recognition in all Government Departments, not the least reason being its financial position in that it represents a capital of at least fifty millions!

The necessity for closer union and co-operation amongst the many societies and associations representing the various interests and activities of chemists had long been felt, but hitherto no definite steps had been taken to effect this object.

In the previous April, however, the President of the London Chemical Society, Prof. (now Sir) William J. Pope, in his address to the Fellows of the Society, emphasised his feeling that the time was now ripe for action in this respect. Shortly afterwards he took active measures to ascertain how far these ideas could be translated into practice, and it is a pleasure to be able to chronicle that his efforts met with such success that a Federation was quickly established under the title of "The Federal Council for Pure and Applied Chemistry, to advance, safeguard, and voice the interests of Chemical Science." The constituent bodies of this Council are the Chemical Society, the Society of Chemical Industry, Association of British Chemical Manufacturers, Institute of Chemistry (co-opted), Society of Public Analysts, Faraday Society, Biochemical Society, Institute of Brewing, Society of Dyers and Colourists, Ceramic Society, and Society of Glass Technology. Since its foundation the Iron and Steel Institute has also joined. A committee of this Council has been appointed to take steps towards establishing an Association or Guild of Chemical Societies, and the provision of a house for its accommodation, where all meetings could be held and the official staff located together with a complete library. Action has also been taken by the Council in several important matters of the utmost concern to the profession. The Institute of Chemistry was not included as a constituent body, but co-opted in order that it might be free to pursue an independent course of action, if deemed advisable, in accordance with the provisions of the charter.

This for the moment completes the edifice as far as Great Britain is concerned, and the future activities of these bodies must lead to a closer Union and even amalgamation, which is not only pregnant with great possibilities, but is certain to achieve great results.

As far as it is possible to foresee what the future has in store, I venture to think that the functions of each section or Society will become more clearly defined, and that the Institute's sphere of action will cover the more professional, ethical, and possibly economic side of our work, while doubtless at the same time becoming the sole registration authority. It is noteworthy in this connection, and with reference to our own labours here concerning Government appointments, that the Public Appointments Committee of the Institute recently formulated a scheme for a Government Chemical Service, which was sent to the Departments concerned, and included the following:—

1. The appointment of Chemists to be based on a system of selection by properly constituted authority and not by examination or nomination.

2. The final selection from the short list of approved candidates to be made by the head of the Government Chemical establishment concerned.

3. The chemists to be graded as civil servants in the higher division, with status, emoluments, and pension comparable with those of the other technical and learned professions employed by Government.

4. Assuming efficiency, promotion up to a definite rank to be guaranteed and made independent of the occurrence of vacancies.

5. Suitable titles to be allotted to the different ranks of chemists.

6. Definite salary-scales to be laid down for all grades.

7. The secondary staff (not to be called chemists) to be subdivided into—(*a*) Chemical Assistants (Senior and Junior), who should be men of good education but without full professional qualifications; (*b*) Laboratory Assistants (Chief, Senior, and Junior), who should be able to perform simple chemical operations and assist the chemists in routine work; (*c*) Laboratory Attendants (Senior and Junior), who would do the work of caretakers, clean apparatus, &c., and have prospects of promotion.

It will be seen that these recommendations are practically coincident with those arrived at by your own sub-committee for submission to the Public Service Commission here in the near future.

Simultaneously with these movements in Great Britain the first general convention of Canadian Chemists was held at Ottawa on May 21, 1918, when it was unanimously decided to form an Association on similar lines to those in England, and the organisation of a national Society is now being undertaken. The formation in 1917 of the Australian Chemical Institute, with branches in every State, with similar aims and objects, is doubtless well known to all.

Our own Association, founded in 1912, may therefore claim to have been well in the advance, and it is a source of great gratification to find that its work, as shown by the steady increase in its membership year by year, meets more and more with the approval of the profession. Its standing and membership are such that it can now speak and act with authority on behalf of the profession in South Africa, which, needless to say, it has done on more than one occasion. To those few who still elect to pursue their lonely way I would venture to address the words of Bacon, written more than 700 years ago, namely, "I hold every man a debtor to his profession, from the which, as men, of course, do seek to receive countenance and profit, so ought they of duty to endeavour themselves by way of amends to be a help and an ornament thereunto." In other words, "Eendracht Maakt Macht," or "Union is strength," an adage overwhelmingly exemplified in these modern days, and from which we can derive inspiration—in fact, must, or otherwise we fail not only in our duty to the nation, but also to ourselves.

It is also a source of gratification to know that the South African Association of Assayers is now an accomplished fact, and the mutual goodwill and understandings between the Association, whilst in process of formation, and our own are a happy augury for the future. The recognition of their work by the State a few years ago is sufficient evidence of our feelings and attitude towards their particular branch of the profession, and I venture to hope that those who are able to satisfy the qualifications necessary for admission to our Society will join and assist the scientific portion of our work by original contributions, whilst at the same time defending their economic interests by membership of their own Association.

The cataclysmic events of the last four years have shaken the world to its foundation, and there is neither a people nor a State which has not been affected in some degree. Those in closest proximity, which have borne the heat and burden of the day, have been the most profoundly influenced to an extent that is somewhat difficult to gauge at the present moment. The prosecution of the war by the most highly-developed and organised nation from a chemical point of view necessitated the provision of like facilities as a means of defence for their opponents, and their establisment transformed Great Britain

at one bound into a huge chemical factory. This remains, and is one of the legacies left by the war, closely connected with which is the efficient control of the raw materials of the Commonwealth. The work of the chemist has been successful in furnishing to the army commanders the weapons of war, and now it will provide the people with the materials necessary in the first instance for life itself, and secondly for the arts of peace.

The shortage of dyes for the manufacture of textiles at the commencement of the war is now a classic example of the scant encouragement given to British chemical industry, but during the last year of the war the production of dyes was 75 per cent to 80 per cent of the whole consumption of the country, as compared with 20 per cent in 1914, a feat accomplished by State aid and encouragement. Glass for chemical, optical, thermal, and other uses is another industry created by the war, as also the manufacture of tar distillation products, synthetic drugs, and perfumes; salts of the rare earths for incandescent mantles and flaming arcs, photographic chemicals and fundamentals, such as intermediates, fuming sulphuric and nitric acids, have also been produced in greatly increased quantity.

The manner in which the necessity for these industries was forced one after another to the notice of the Government affords some painful illustrations of the colossal ignorance of our science by administrators and politicians. Two examples will suffice. Shortly after war broke out a committee of British steel manufacturers informed the Government that they would be able to continue operations for a few weeks longer only, and then be practically compelled to shut down their works owing to the exhaustion of the glassware required for the laboratory control of the works operations. The crisis demanded the immediate production of the needed chemical glassware, which was quickly met by the efforts of a Committee of Chemists summoned by the Institute. Again, administrative officialdom allowed the free importation of lard and other fats into Germany at the beginning of the war. These are substances from which glycerin and in turn nitroglycerin are manufactured. When the chemists drew attention to this fact, an official is stated to have explained that this was a recent German discovery, and therefore the British Government could not be expected to know it!

We are not foolish enough to ask that none but chemists should occupy the highest administrative posts, but, on the other hand, we do demand most emphatically that those who hold them should be enlightened enough, either by training or otherwise, to have some knowledge, however slight, of the basic nature of our work and the necessity of its vital importance for the well-being of the nation. The organisation of the chemical world outlined above was a direct consequence of the many crises engendered by the war, and it will now remain as a protecting shield against the commission or repetition of blunders similar to those mentioned. The Right Hon. H. A. L. Fisher, Minister of Education, speaking at the anniversary dinner of the London Chemical Society, said that "the educational cause, which Huxley championed, may now be regarded as practically won, and former sceptics must have been converted by the achievements of science in the war; there was, however, leeway to be made up, and a great deal more money must be spent on science. If warfare was to be a thing of the past, chemistry would be the principal agent of that beneficent change. It would have done more than any league of nations could possibly aspire to do. We realised, he hoped, that the best form of protection for national industry was not more tariff but more chemistry."

In the United States of North America a similar state of affairs was prevalent as in Great Britain, and a similar awakening had taken place. Her chemical war service called into action hundreds of her most prominent chemists, and her organisation initiated researches as well as industries of large dimensions. The layman began to realise the chemist's function, and what it is possible for him to accomplish. With this enlightenment came also the appreciation of the daily press, but in this respect American chemists of distinction state that much spadework is yet necessary before a real advance can be accomplished. Unfortunately, it is our lot to tell the same tale in spite of the spontaneous offer of your Council to lend its aid. I still remember well finding in glaring headlines in the most prominent page of one of our dailies the announcement of a new (and great!) chemical discovery, which I naturally absorbed with some avidity, only to find that some obscure person had "invented" a liquid which would, when poured over hardibank, crumble it at once to powder, and discover without further effort the diamonds enclosed in its siliceous shell! Before 10 o'clock the same morning I was consulted by a gentleman who possessed a mine where the blue ground was of this character, with regard to this announcement, in which he expressed his implicit belief! Statements almost as ludicrous as those have been repeated in the press regarding German dyes during the recent war.

Again, the work of the pharmacist is often confused with that of the chemist in the public mind. According to one of the most prominent official editors in pharmacy, the fortunes of pharmacy as a profession are inextricably bound up with English legislation affecting the sale of poisons dating from 1868, by which Parliament proposed to provide an educated class of dispensers and sellers of poisons. That it has nobly fulfilled the duties for which it was created is not open to question, but the title of chemist is one which cannot be claimed with justice or maintained with equity. The profession of pharmacy enjoys the protection of State legislation, being equal in this respect to the profession of law and medicine, and one of our main objects is to secure for our profession a similar status to that which it has been their privilege to enjoy. The great achievements of the war period from the foundation of the edifice and the universal movement for unification of interests is evidence of its future success.

The industrial supremacy of the future is intimately bound up and most closely interwoven with the welfare and work of the chemist. The conservation of national resources, more especially of energy or coal, is a subject which few nations can take the risk of shirking. Scrap and waste are by-products which the chemist will convert again to profitable uses. To secure this will require educational opportunities of the highest character the State can afford, qualifications commensurate with the work to be undertaken, protection from the charlatan and the quack, and the liberal endowment of facilities for research. In these respects South Africa has yet far to go, but if the lessons of the war have made any impressions whatever they should quickly mature, as they have done already in the older countries, whose economic burdens demand a searching reconstruction of the ways and means of utilising every resource for the welfare of the nation. In the fierce competition which is sure to arise in the near future the nation which looks askance at the possibilities within the chemist's grasp will be guilty of strangling of her own infant industries and retarding her own evolution. What the nation requires, and should demand, is progressive development based on scientific methods, and what the chemist seeks is the opportunity for service.

In conclusion, it is my duty and my pleasure to render to you my thanks for the honour you and your Council did me in calling me to preside over your Association for the past year.

Without it has been fraught with fateful events, within a year of steady progress, for which you are indebted to a Council, ever mindful of the goal in view, and ever watchful of your interests, to which, as well as to your Honorary Secretary, I personally feel a deep debt of gratitude for the ever-ready and willing assistance they have so freely rendered.

FEDERATION OF BRITISH INDUSTRIES.

In pursuance of the policy of placing Trade Commissioners in foreign countries, the following appointments have been made by the Overseas Committee of the Federation of British Industries, and have been approved:—

Italy: Mr. E. H. Capp. Mr. Capp was previously the energetic and successful Secretary of the British Chamber of Commerce for Italy, whose headquarters were at Genoa, with other offices at Milan and Rome. He will open an office for the Federation of British Industries at Milan at an early date. He has a very extensive knowledge of business and commercial circles in Italy, and his previous experience will be extremely valuable. The address of the Federation's office in Italy will be communicated to the Press as soon as possible.

Portugal: Mr. G. L. Barley. Mr. Barley has a very full knowledge of Portugal. His address will be—Care of Messrs. Rugeroni and Rugeroni, Ltd., Rua I° de Dezembro 82/84, Lisbon.

Algiers: Mr. E. Dorrien Thoroton. His address will be—Federation of British Industries, 6, Rue De La Liberte (Cox and Co.), Algiers.

Near East (Constantinople): Capt. Lafontaine. Capt. Lafontaine is well known in Constantinople, where his family has been resident for many years. For some time previous to the war he represented the well known firm of Messrs. Whittalls in this area with great success. Capt. Lafontaine will open an office for the Federation of British Industries in Constantinople at an early date. This address will also be communicated to the Press as soon as possible.

The Algiers and Portugal offices will act under the supervision of the Federation's Trade Commissioner in Madrid, Colonel Thoroton.

The Constantinople office will act under the supervision of the Federation's Trade Commissioner in Athens, Major Kennard.

VISIONS OF A EUROPEAN FINANCIAL CRISIS.

Some cryptic remarks, illustrating how a financial crisis must irretrievably devastate the whole of Europe and adversely affect the world generally, if America does not back the Allies financially and if the League of Nations does not soon become an accomplished fact, were delivered by Sir George Paish at a meeting held in the Council Chamber at the Guildhall under the auspices of the Industrial League and Council, and presided over by Lord Parmoor.

"I am glad to see," said Sir George Paish, "that the British Government has promised to assist France in raising a great Loan. France needed to purchase an immense quantity of food and raw material, while it had little or no exporting power. From the foreign trade figures for France, he thought the amount of their exports would only be about 160 millions for the current year, whereas their imports would not come far short of 900 millions. That could not go on, and France would need very large sums of money to protect its exchange. England must help to provide that money. But how was that to be done, since their own position was not without danger? In the current year their imports would exceed their exports by something like 700 millions, and they were only enabled to pay their way because they still derived approximately 150 millions a year from foreign investments. In addition, owing to the high freight rates, they also obtained something like 400 millions a year from their shipping. Altogether, England's invisible exports were probably about 650 millions. Their danger, therefore, came from their failure to produce and pay their way. It arose from the fact that they had to sell to nations who were unable, for the moment, to pay for what they received. They were sending to the Continent goods to the value of 600 millions per year, and received in payment goods to the value of 200 millions. They had got to wait for it, and might eventually have to give it. This country was also purchasing from America in the current year goods to the value of 550 millions, and, on the other hand, was only exporting to America for the same period goods which might reach to the value of 30 millions. This meant that England had either got to borrow, or sell to America securities to the value of 500 millions. How long that could go on would depend upon the assistance they received from America. They were entitled to ask them for it, not for their own sakes, but in order that England might continue rendering to France, and the Continent generally, the services which they were at present giving. If America, then, failed, then England would not be able to buy food or raw material or help the Continent; England would be starved, and so would the Continent. It was therefore essential that America should provide the credit Europe needed. According to Mr. Hoover's calculations, 100 millions of people were in danger as a result of the war. They would realise how essential it was to prevent such a situation ever occurring again. War was impossible. England realised it; he believed that America did, but he was not sure that the Continent did. They would before they were through, as their very existence depended upon a strong and powerful League of Nations. Further, who was to find the credit for the whole of Europe unless they had some such organisation which would back all the bills? Nations were in trouble. Someone had got to back their bills for them, not for the sake of business, but for the sake of humanity; and the only conceivable organisation powerful enough to take a grip of this situation was a League of Nations. Before Europe could possibly become self-supporting, its devastated districts had got to be restored. It was true the Peace Treaty arranged for payment by the enemy countries, but those countries were in difficulties, and had got to be provided with facilities to enable them to pay. Europe's productive power could not be restored until Europe's credit and its devastated disrricts were restored. Only a powerful League of Nations was conceivably strong enough to back such a financial situation. Countries which themselves were in debt could not go on lending indefinitely."

If the League of Nations was not brought into being, England would have to begin to prepare for another war. Their Budget would be so immense that they would have no money for capital purposes. The City of London would go out of business, and would cease to be the world's bankers. The maintenance of the great British Empire depended upon it. When the League of Nations came into existence, it would mean that the future Government of the world would be controlled by the democracy of the world, and they would arrive at that position towards which the progress of mankind through many centuries had been directed."

Lord Parmoor said he would like to add a corollary with which he thought they would not disagree. International inter-dependence and inter-communication and a League of Nations to be effective must be a league open to all countries and not limited to special countries. They must be prepared in the spirit and goodwill to meet those towards whom, not unnaturally, they might have feelings for the moment of animosity and reproach. This was especially true as regards economic co-operation. There would have to be no objections put in the way of particular countries, and especially no restrictions in the way of those countries which had suffered much, no matter whether they were allies or their enemies.

Tha meeting concluded with the customary vote of thanks.

Juvenile Lectures.—At the Royal Society of Arts, on Wednesdays, January 7 and 14, 1920, Mr. Loughnan Pendred, Editor of the *Engineer*, will deliver two Lectures to Juveniles, on "Railways and Engines."

PROCEEDINGS OF SOCIETIES.

SOCIETY OF CHEMICAL INDUSTRY.
(Birmingham and Midland Section).

Thursday, December 14, 1919.

At this meeting, held at the University of Birmingham, under the presidency of Mr. L. P. Wilson (Coventry), the following interesting paper was read by Mr. Knapp :—

"*Action of Water on Lead.*" By A. W. Knapp, B.Sc., F.I.C., and J. F. Liverseege, F.I.C., Ph.C. (City Analyst, Birmingham).

It is well known, the authors pointed out, that many waters act on lead. This action was made the subject of extended experiments by Dr. Houston, who invented the erosion test. The question is of considerable importance from the point of view of public health, and the conditions under which lead is eroded are of interest in relation to the uses of lead in the arts. The waters which Dr. Houston examined were acid in character and notable for their power of dissolving lead.

On the other hand, their experiments dealt with a fairly alkaline natural water, which, like distilled water or pure rain-water, dissolved very little lead, but which had in the untreated condition the power of eroding the lead, so that scales formed on it fall away, leaving a fresh bright surface open to attack. The erosive ability was not considered by Dr. Houston to be a dangerous quality, save under special conditions and in the presence of bright lead. The water used in the tests was from the Birmingham watershed at Rhayader, in Wales. In order to avoid any risk of so soft a water acting on lead, a small proportion of chalk is added to the water at the beginning of the aqueduct; the usual addition in recent years has been about two parts per 100,000. The alkalinity is determined as follows :—

To 500 cc. of water in a porcelain basin phenolphthalein is added, and if a red colour is produced the liquid is titrated cold with decinormal hydrochloric acid; lacmoid is then added, and the titration completed whilst boiling. The Welsh water (Rhayader) has a slight alkalinity, due to bicarbonates, &c., equal to about 0·3 part $CaCO_3$ per 100,000. The action on lead is mainly erosive.

The erosion test is an estimation of the action of the water on completely immersed sheet-lead. The value of the test lies in the fact that a high erosion figure is an advance warning that the water in its fluctuations may be approaching a dangerous condition. The erosion test is performed with bright lead in water with free access to air, and under these conditions a water will erode lead when it is unable to act on lead service pipes to any extent. The kind and position of the erosion will depend on a number of conditions, the chief of which is alkalinity. Three kinds of action occur. With waters of alkalinity 0·2 to 0·6 (*i.e.*, untreated Welsh waters), and generally with treated waters whose alkalinity does not exceed 1·5, the whole of the surface of the lead is eroded. A flocculent precipitate forms which falls to the bottom of the tube and leaves the lead surface quite bright but mottled. With treated waters of alkalinity 1·5 to 2·5, the action is usually corrosion rather than erosion; a loosely held opaque white crust forms here and there irregularly on the lead surface. With waters of alkalinity 2·5 and over, the lead almost invariably becomes covered with a dull whitish film, which appears to act as a protective coating. (The expression "the alkalinity was 2·8" means that the total alkalinity, expressed as parts $CaCO_3$ per 100,000 of water, was 2·8). In performing the erosion test commercial sheet lead is used in strips one-half inch wide and about one-eighth inch thick (one square foot weighs 4·3 lbs), is scraped bright with a plumber's shave hook, and cut into lengths of one inch. Each piece is rubbed with a clean duster; 10 cc. of the water is poured from a cylinder into the test-tube, and the strip of lead polished with a cloth and dropped into it, the lead being totally immersed. The tube is shaken to remove air bubbles; it is then allowed to stand for one, three, seven, or fourteen days. If there is no evidence of erosion, the water is decanted into a 50 cc. Nessler cylinder and the lead strip shaken with about 10 cc. of distilled water, which is poured into the cylinder. The lead is then removed and the tube washed with 5 cc. of dilute acetic acid (roughly decinormal) and with water until there is 50 cc. in the cylinder. If erosion is doubtful, the water is decanted into a 50 cc. Nessler cylinder, the lead dropped into a funnel, and any eroded lead washed off with a jet of water into the cylinder, dilute acetic acid being used as before. If there is evident erosion, the turbid water is decanted into a 100 cc. flask, the lead shaken out into a funnel, and allowed to stand a short time before it is emptied into the flask. The tube is washed with more distilled water, and the flask filled up to the mark. When the solution is quite clear, 50 cc. or a smaller measured quantity is put into a Nessler cylinder and made up to 50 cc. Comparison is made in 50 cc. cylinders; 5 cc. of the dilute acetic acid and 3 cc. of saturated sulphuretted hydrogen are added to every cylinder. The colour produced by the colloidal lead sulphide is matched by standards put on at the same time. The standards are made with distilled water—except in the case of very dark waters. when it is advisable to include 10 cc. of the original water. The standard lead solution used is of such a strength that 1 cc. = 0·0001 grm. Pb; it is prepared from a solution a hundred times its strength, which contains 1·831 grms. lead acetate and 10 cc. normal acetic acid per 100 cc. Standards may be increased by 0·1 or 0·2 cc. of the lead solution after the sulphuretted hydrogen has been added, but these standards are not so reliable as those to which the sulphuretted hydrogen is added last.

"Erosion" is due to the action of oxygen in the presence of water, such variations as occurred naturally in the percentage of oxygen present in the water produced no appreciable effect on the erosion. One day is the most suitable period for the erosion test. Exposure to glass lowers the water's erosive ability. In some experiments on the influence of contact with glass of test-tube, ordinary tubes were compared with those which had been coated internally with a thin layer of paraffin wax. The mean alkalinity of the water was 2·3. The results showed that the paraffin-coated tubes gave no better duplicates than ordinary tubes, and that the erosion figures in paraffin-coated tubes were higher. Mean of thirteen tests—Paraffin-coated, 4·7; ordinary, 3·8. The greater the depth at which the lead is immersed in the water, the slower the erosive action. The velocity of erosion falls as time proceeds; variation in the volume of water does not appreciably affect erosion. For the untreated water the amount of lead eroded varies directly with the area of lead exposed. Small changes in the area of the water surface produce no appreciable effect on the erosion. Erosion readily occurs in waters which contain no carbon dioxide. Such variations as occurred naturally in the percentage of carbon dioxide present in the water produced no appreciable effect on the erosion. The presence of from 1 to 2 per cent of carbon dioxide causes a sudden change from "erosion" to "plumbo-solvency." Carbon dioxide dissolves lead more rapidly in the presence of oxygen. The question may be asked if the presence of carbon dioxide is necessary for erosion to occur. All the evidence we have goes to show that it is not necessary. Erosion takes place readily in the absence of free carbon dioxide; for example, when 1 to 200 parts of calcium hydrate per 100,000 are present. And, further, erosion takes place less rapidly in the presence of bicarbonate and carbon dioxide than with carbonate and hydrate alone. Under normal conditions, for ordinary waters, carbon dioxide is an unimportant factor. Given oxygen, the alkalinity of the water is the principal factor determining the amount of "erosion." Not only the amount but the kind of erosion depends chiefly on the alkalinity of the water. The addition of small quantities of calcium hydrate,

carbonate, and bicarbonate, or of potassium permanganate, decrease erosion. Experiments show that as the amount of calcium hydrate present in the water increases, the amount of lead eroded falls to a *minimum* when there is present about 7 to 10 parts of calcium hydrate per 100,000. After this point, increase in the calcium hydrate causes increase in the erosion, which gradually attains about its original amount. As the amount of carbonate and bicarbonate present in the water increases, the amount of lead eroded continually falls. Calcium carbonate is by far the most effective preventer of erosion. Only about half the quantity of bicarbonate is required to form a protective coating as compared with carbonate. This would receive a theoretical explanation if, as seems probable, the coating is a carbonate of lead. As little as 2 parts per 100.000 of calcium carbonate is generally sufficient to form a plumbo-protective coating on the lead. Erosion occurs in the absence of bacteria. The bacteria in the water are not all destroyed by exposure to lead for six hours.

NATIONAL ASSOCIATION OF INDUSTRIAL CHEMISTS.

The National Association of Industrial Chemists—which claims to be the only Association which cares for the interests of all analytical chemists—is progressing favourably. At the recent meeting of the Executive Council a further increase in membership was reported, and the Association has now appointed a full time Assistant Secretary. It has also been registered under the Trade Union Act, and is the only body representing analytical chemists in the United Kingdom which is so registered.

With the newer powers thus granted to it the Association anticipates a considerable increase in its influence and in its ability to assist the economic condition and pro fessional status of its members.

Its educational work is carried out on progressive lines, a series of lectures by Dr. F. Rogers to the Sheffield Section being very largely attended. The Annual Dinner of the Sheffield Section was also a great success, over a hundred being present. The feature of the evening was a speech by the Chairman (Mr. A. C. J. Charlier) on the omission of all chemists, engineers, technical managers, inspectors, and supervisors—in short, the men with brains—from the joint councils formed under the Whitley scheme, and the necessity for all such men to federate in order to secure adequate representation on these councils.

The Annual Dinner of the Birmingham Section, at which the chief speaker was the Hon. Secretary of the Association, was also a success; about 30 members were present, and the bright and enjoyable evening was made all the pleasanter by the smoking concert which followed the more formal dinner.

Special arrangements are being made to give isolated members as equal share in the management of the Association as those who belong to a London Section. After considerable discussion it was decided to continue the subscription at one guinea for full members and half a guinea for associates. Further particulars can be obtained from the Secretary, The White Building, Sheffield.

NOTICES OF BOOKS.

Iron Bacteria. By David Ellis, D.Sc., Ph.D., F.R.S.E. London: Methuen and Co., Ltd., Essex Street, W.C. Pp. xix+179. Price 10s. 6d. net.

The author's aim in writing this monograph is to bring together material, within the compass of a small book, which would be of assistance to engineers and chemists engaged in the purification of water from bacteria causing corrosion in iron pipes. It is a welcome addition to scientific literature, for he writes on a branch of biology which is not adequately treated in most text-books.

Dr. Ellis commences his book with a description of the bacteria found in natural waters. He accompanies his remarks with micro-photographs, also with diagrammatic sketches. These descriptions are very thorough and should be easily understood by those for whom the book is intended.

Their artificial cultivation is next dealt with, followed by a chapter on the physiology of iron bacteria.

When the kind of organism present in the sample under investigation has been identified, its method of treatment for elimination has to be decided on; this has been dealt with in a very understandable fashion by Dr. Ellis. Well known cases of the contamination of drinking waters by iron bacteria are enumerated, and the causes of same are explained.

Altogether his work is a first-class effort, and should prove a valuable aid not only to the water engineer and chemist but to the biologist.

NOTES.

At a recent meeting of the Birmingham and Midland Section of the Society of Chemical Industry Prof. Morgan, of the Chair of Chemistry at the University of Birmingham, was cordially welcomed. He is the successor of Prof. Percy Frankland. Prof. Morgan said he attended there with deep feelings, for it was in that lecture theatre that his old teacher and predecessor there, Sir Wm. Tilden, formerly lectured.

The Physical Society and Optical Society's Annual Exhibition.—This exhibition, which is to be held on Wednesday and Thursday, January 7 and 8, 1920, at the Imperial College of Science, South Kensington, will be open in both the afternoon (from 3 to 6 p.m.) and in the evening (from 7 to 10 p.m.). Prof. F. J. Cheshire, C.B.E., will give a discourse on "Some Polarisation Experiments" at 8 p.m. on January 7 and at 4 p.m. on January 8, and Prof. A. O. Rankine, D.Sc., will give a discourse on "The Use of Light in the Transmission and Reproduction of Speech" at 4 p.m. on January 7 and at 8 p.m. on January 8. The lectures will be illustrated by experiments. Some forty firms will be exhibiting; and there will also be certain experimental demonstrations. We understand that invitations have been given to the Institution of Electrical Engineers, the Institution of Mechanical Engineers, the Faraday Society, the Wireless Society of London, and the Röntgen Society. Admission in all cases will be by ticket only, and therefore members of the Societies just mentioned (including also the Physical and Optical Societies) desiring to attend the Exhibition should apply to the Secretary of the Society to which they belong. Others interested should apply direct to the Secretary of the Physical Society, National Physical Laboratory, Teddington, S.W.

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